Fence-line Applications

Monitoring VOC´s and Criteria gases in Industrial Areas

Air Quality Monitoring using OPSIS Technology

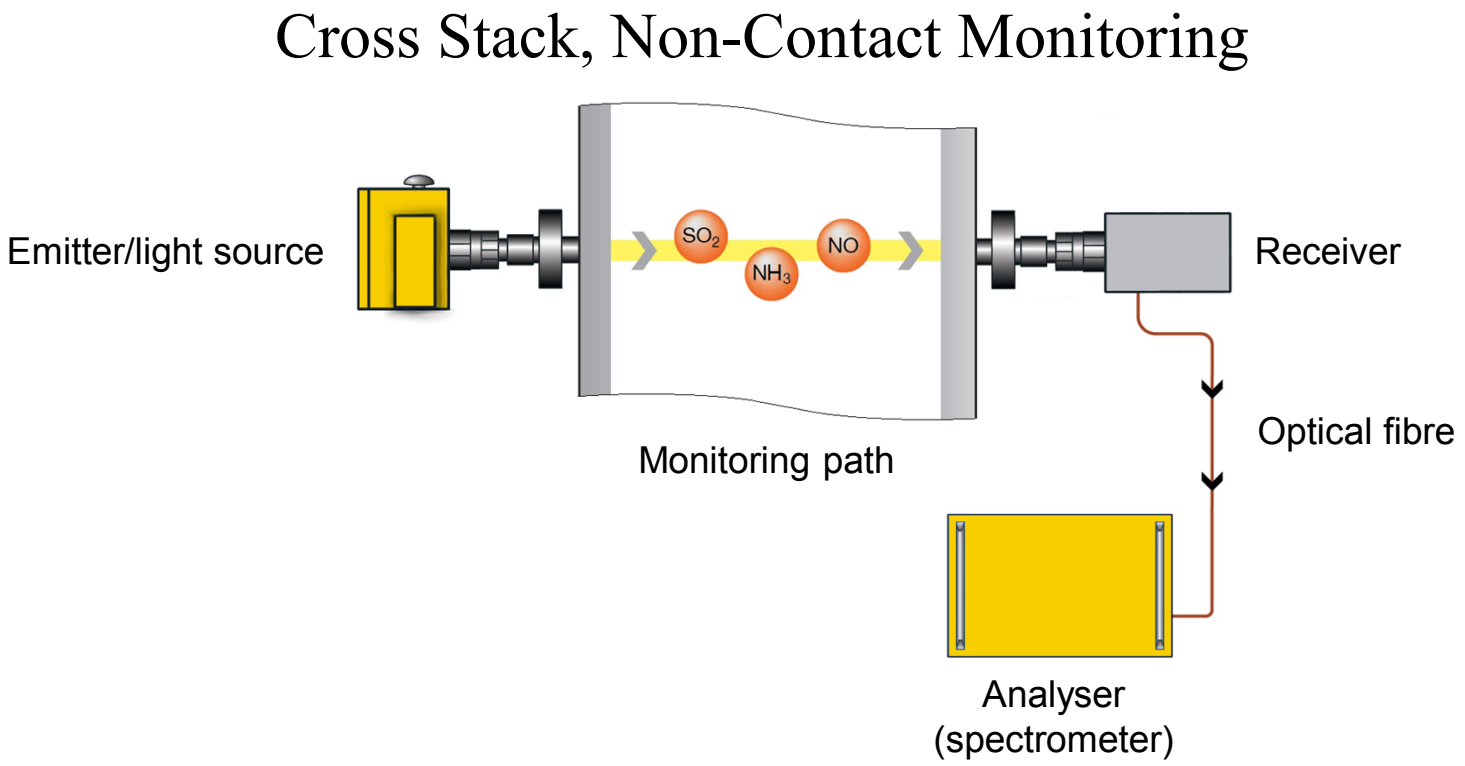
OPSIS at a Glance

- Founded 1985 by Leif Unéus and Svante Wallin
- Spin-off from Lund Institute of Technology, Sweden
- Fundamental idea: monitor air pollution using spectroscopy
- Head office in Furulund since 1991
- About 60 distributors around the world

The OPSIS Company

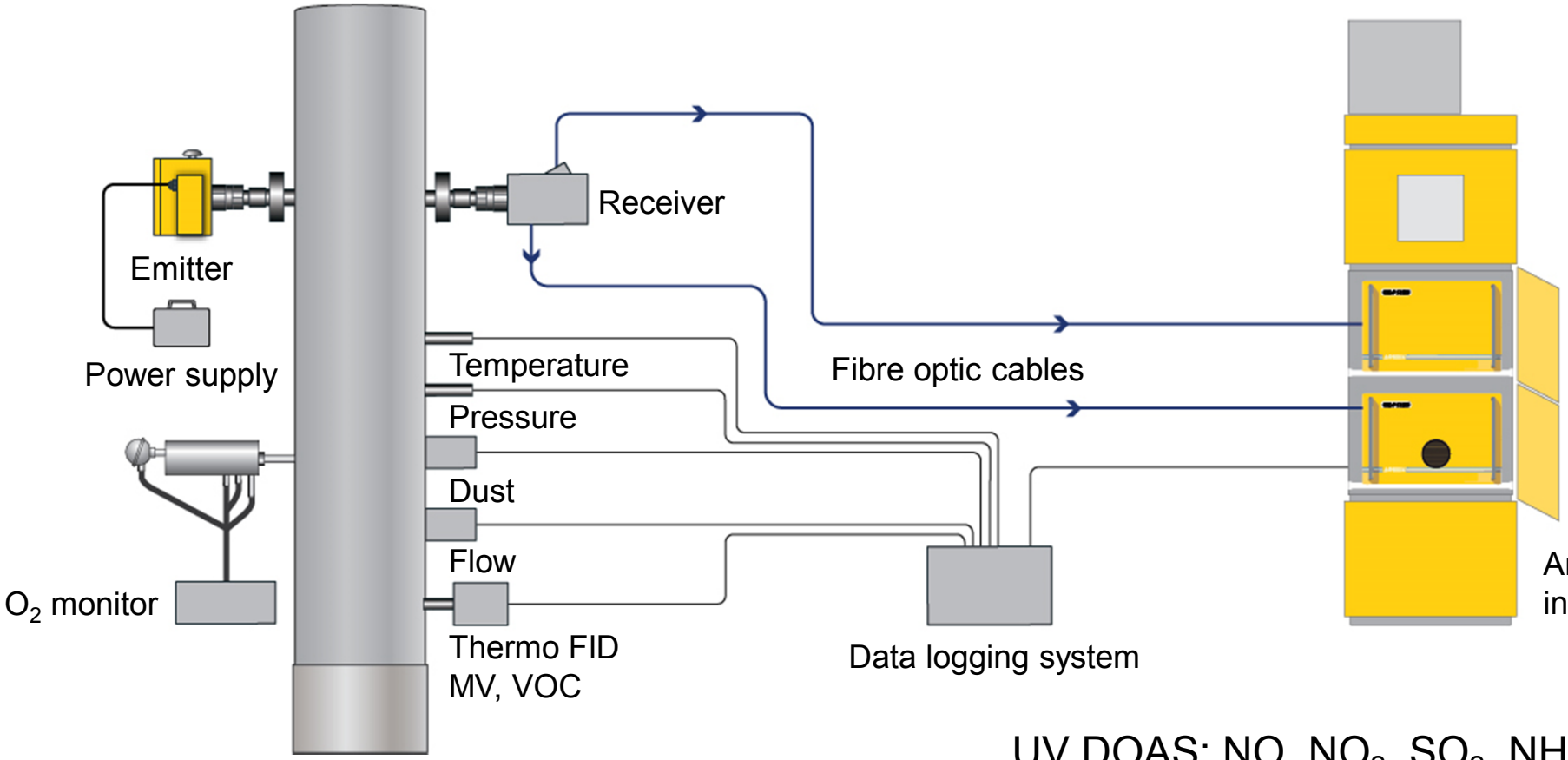
- More than 3,000 monitoring systems sold, worldwide, to every continent
- Understands user needs and applications
- Investing in product certifications and approvals
- A certified business:
  - Quality management system: ISO 9001:2015
  - Environmental: ISO 14001:2015
  - Health and safety: OHSAS 18001:2007
  - Accredited calibration laboratory: ISO 17025

Open-Path DOAS Technology (CEM)



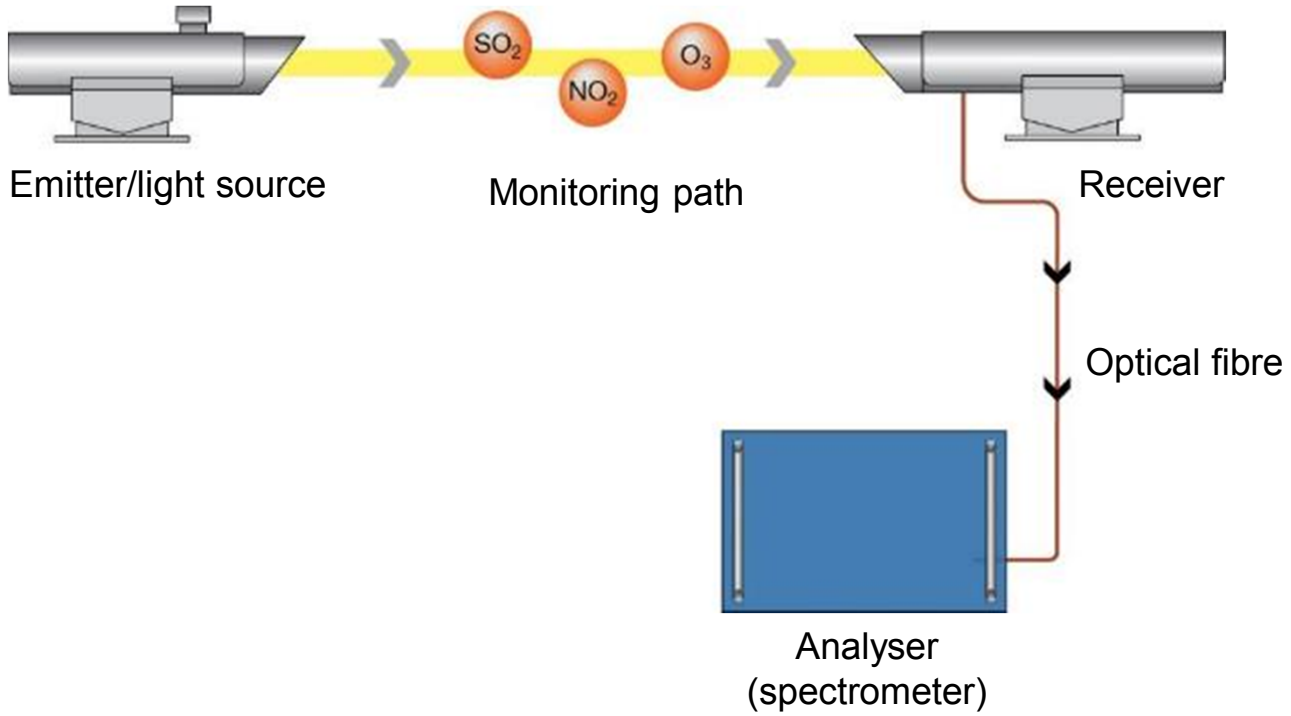
Differential Optical Absorption Spectroscopy

Example , CEM system



UV DOAS: NO, NO_2, SO_2, NH_3, Hg, etc.
IR DOAS: CO, CO_2, HCl, HF, H_2O, etc.

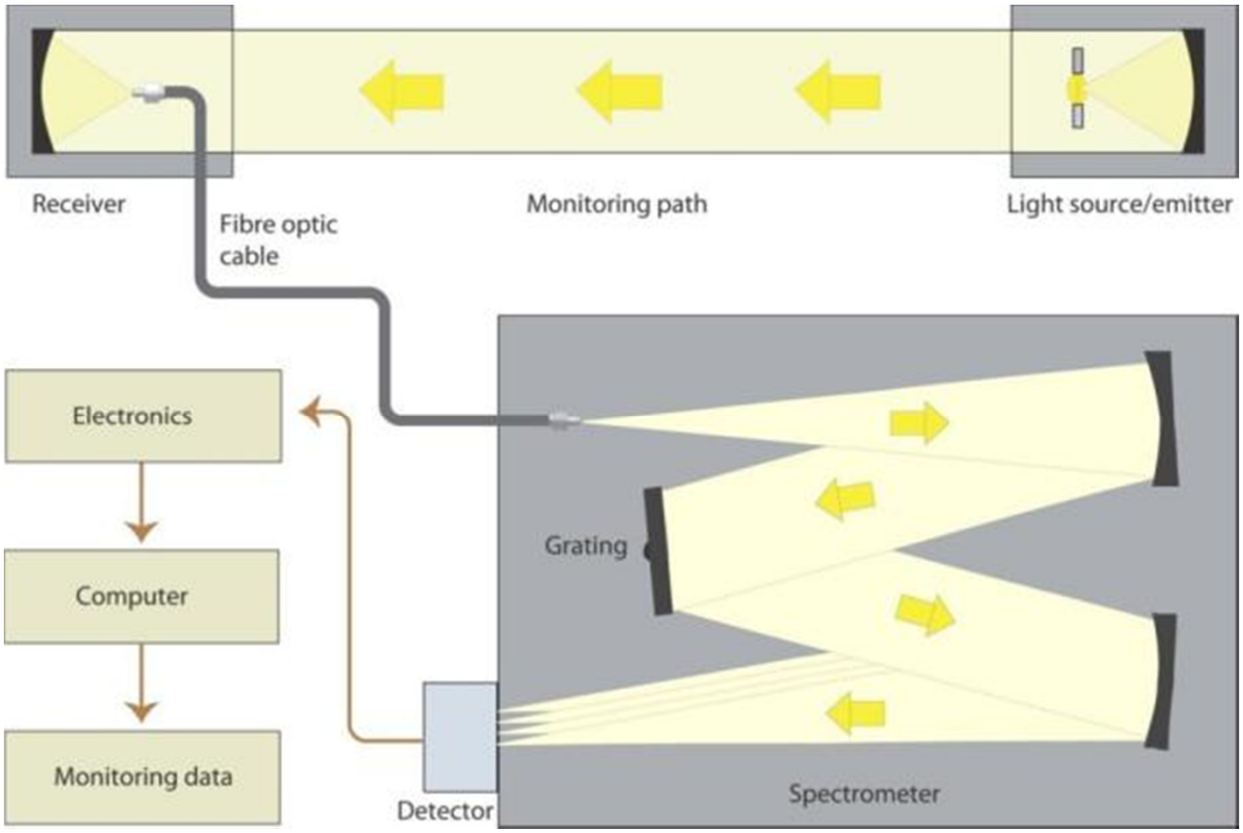
Open Path DOAS Technology (AQM)



Differential Optical Absorption Spectroscopy

UV DOAS TECHNIQUE

DOAS= Differential Optical Absorption Spectroscopy)



For gas compounds such as :

- Nitrogen Oxides (NO, NO_2)
- Ammonia
- Sulfur Dioxide
- Naphtalene
- Benzene
- Toluene
- Xylenes
- Mercury
- Chlorine

and more…

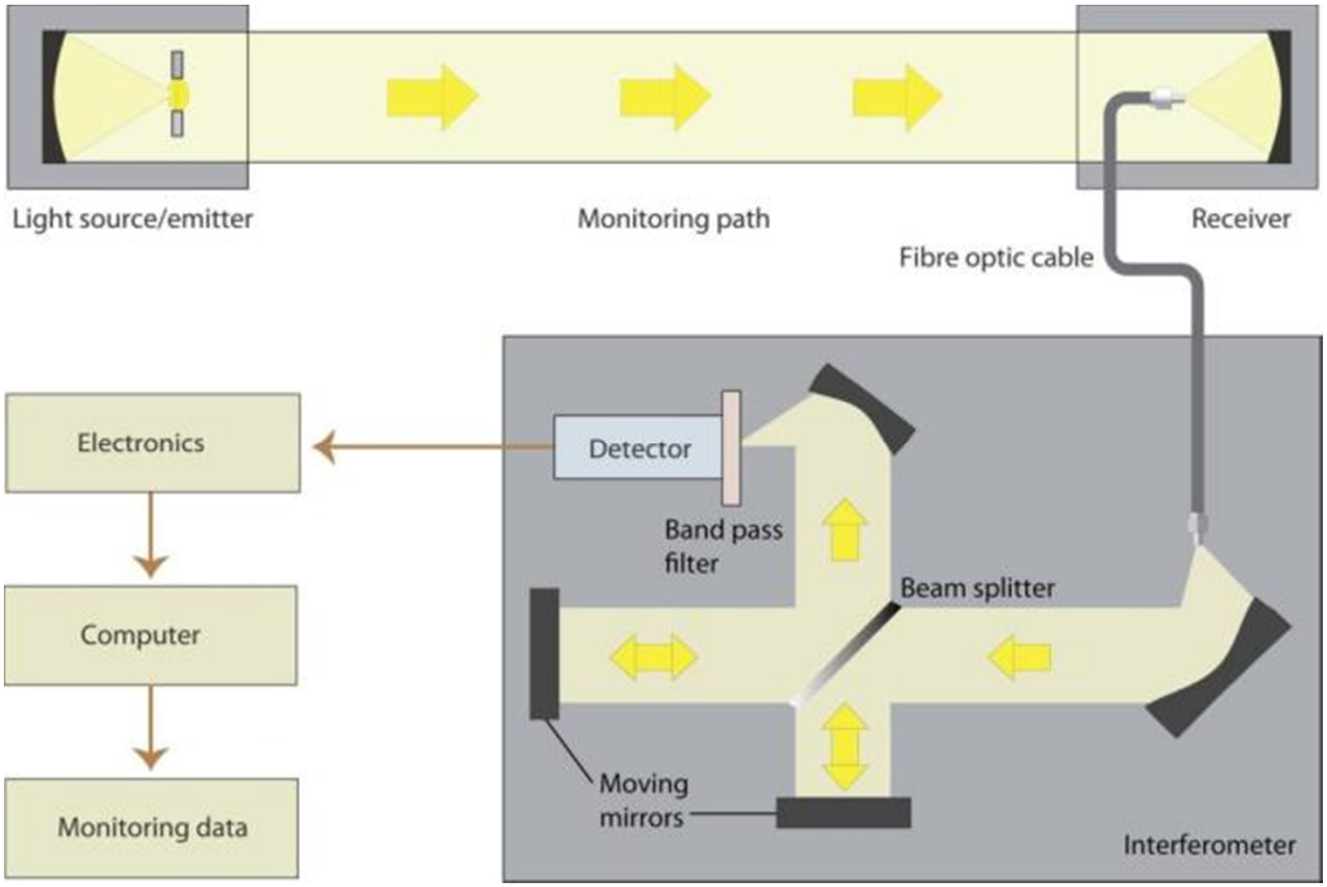
UV/NIR DOAS GASLIST

Performance Data (typical data which may vary depending on application)

Compound	Max. measurement range[3] (500 m path)[4]	Min. detectable quantities (monitoring path 500 m, measurement time 1 min.)	Zero drift (500 m path, max. per month)	Span drift (per month, better than)	Span drift (per year, better than)	Linearity error (of measurement range, better than)	Max. length of fibre optic cable (when measuring several compounds)[1]	Hardware requirement
AR500/AR520 UV/IR DOAS Analyser								
NO_2	0-2000 µg/m³	1 µg/m³	±2 µg/m³	±2%	±4%	±1%	10 m	AR500/520
SO_2	0-5000 µg/m³	1 µg/m³	±2 µg/m³	±2%	±4%	±1%	10 m	AR500/520
O_3	0-1000 µg/m³	2 µg/m³	±4 µg/m³	±2%	±4%	±1%	10 m	AR500/520
NO[2]	0-2000 µg/m³	2 µg/m³	±4 µg/m³	±2%	±4%	±1%	10 m	AR500/520
NH_3[2]	0-500 µg/m³	2 µg/m³	±4 µg/m³	±2%	±4%	±1%	10 m	AR500/520
NO_3	0-500 µg/m³	0.1 µg/m³	±0.2 µg/m³	±2%	±4%	±1%	10 m	AR500/520
HNO_2	0-2000 µg/m³	1 µg/m³	±2 µg/m³	±2%	±4%	±1%	10 m	AR500/520
HF	0-2000 µg/m³	20 µg/m³	±40 µg/m³	±2%	±4%	±1%	10 m	AR520
Hg	0-2000 ng/m³	20 ng/m³	±40 ng/m³	±2%	±4%	±1%	10 m	AR500/520
H_2O	0-100 g/m³	0.2 g/m³	±0.4 g/m³	±2%	±4%	±1%	10 m	AR520
Styrene	0-2000 µg/m³	5 µg/m³	±10 µg/m³	±2%	±4%	±1%	10 m	AR500/520
CS_2	0-2000 µg/m³	20 µg/m³	±40 µg/m³	±2%	±4%	±1%	10 m	AR500/520
Cl_2[5]	0-10000 µg/m³	50 µg/m³	±100 µg/m³	±2%	±4%	±1%	10 m	AR500/520
Formaldehyde	0-2000 µg/m³	2 µg/m³	±4 µg/m³	±2%	±4%	±1%	10 m	AR500/520
Acetaldehyde	0-2000 µg/m³	20 µg/m³	±40 µg/m³	±2%	±4%	±1%	10 m	AR500/520
Phenol	0-2000 µg/m³	1 µg/m³	±2 µg/m³	±2%	±4%	±1%	10 m	AR500/520
Benzene	0-2000 µg/m³	1 µg/m³	±2 µg/m³	±2%	±4%	±1%	10 m	AR500/520
Toluene	0-2000 µg/m³	1 µg/m³	±2 µg/m³	±2%	±4%	±1%	10 m	AR500/520
p-, m-Xylene	0-2000 µg/m³	1 µg/m³	±2 µg/m³	±2%	±4%	±1%	10 m	AR500/520
o-Xylene	0-2000 µg/m³	10 µg/m³	±20 µg/m³	±2%	±4%	±1%	10 m	AR500/520
o-, m-, p-Cresol	0-2000 µg/m³	5 µg/m³	±10 µg/m³	±2%	±4%	±1%	10 m	AR500/520
C_6H_5Cl	0-2000 µg/m³	5 µg/m³	±10 µg/m³	±2%	±4%	±1%	10 m	AR500/520
$C_6H_4Cl_2$	0-2000 µg/m³	5 µg/m³	±10 µg/m³	±2%	±4%	±1%	10 m	AR500/520
ClO_2	0-2000 µg/m³	1 µg/m³	±2 µg/m³	±2%	±4%	±1%	10 m	AR500/520
Cresol	0-2000 µg/m³	5 µg/m³	±10 µg/m³	±2%	±4%	±1%	10 m	AR500/520
$COCl_2$	0-2000 µg/m³	5 µg/m³	±10 µg/m³	±2%	±4%	±1%	10 m	AR500/520
Ethylbenzene	0-2000 µg/m³	5 µg/m³	±10 µg/m³	±2%	±4%	±1%	10 m	AR500/520
Acrylonitrile	0-2000 µg/m³	5 µg/m³	±10 µg/m³	±2%	±4%	±1%	10 m	AR500/520
1,2,4-Trimethylbenzene	0-2000 µg/m³	5 µg/m³	±10 µg/m³	±2%	±4%	±1%	10 m	AR500/520
1,3,5-Trimethylbenzene	0-2000 µg/m³	5 µg/m³	±10 µg/m³	±2%	±4%	±1%	10 m	AR500/520

IR DOAS TECHNIQUE

DOAS= Differential Optical Absorption Spectroscopy)



For gas compounds such as :

- Hydrogen Chloride
- Carbon Monoxide
- Carbon Dioxide
- Hydrogen Fluoride
- Moisture
- Bromine
- Iodine
- Methane
- Propane
- Ethane
- Hydrogen Sulfide
- Total Hydrocarbons

and more…

IR-DOAS GASLIST

Performance Data (typical data which may vary depending on application)

Compound	Max. measurement range[3] (500 m path)[4]	Min. detectable quantities (monitoring path 500 m, measurement time 1 min.)	Zero drift (500 m path, max. per month)	Span drift (per month, better than)	Span drift (per year, better than)	Linearity error (of measurement range, better than)	Max. length of fibre optic cable (when measuring several compounds)[1]	Hardware requirement
AR550 IR DOAS Analyser[2]								
Acetic acid	0-200 mg/m³	0.1 mg/m³	±0.2 mg/m³	±2%	±4%	±1%	10 m	AR550
Acetone	0-200 mg/m³	0.05 mg/m³	±0.1 mg/m³	±2%	±4%	±1%	10 m	AR550
Acetyl chloride	0-200 mg/m³	0.1 mg/m³	±0.2 mg/m³	±2%	±4%	±1%	10 m	AR550
Acetylene	0-200 mg/m³	0.05 mg/m³	±0.1 mg/m³	±2%	±4%	±1%	10 m	AR550
Allyl alcohol	0-200 mg/m³	0.1 mg/m³	±0.2 mg/m³	±2%	±4%	±1%	10 m	AR550
Benzaldehyde	0-200 mg/m³	0.1 mg/m³	±0.2 mg/m³	±2%	±4%	±1%	10 m	AR550
1,3-Butadiene	0-200 mg/m³	0.05 mg/m³	±0.1 mg/m³	±2%	±4%	±1%	10 m	AR550
Butane	0-200 mg/m³	0.1 mg/m³	±0.2 mg/m³	±2%	±4%	±1%	10 m	AR550
n-Butyl alcohol	0-200 mg/m³	0.1 mg/m³	±0.2 mg/m³	±2%	±4%	±1%	10 m	AR550
CO	0–100 mg/m³	100 µg/m³	±200 µg/m³	±2%	±4%	±1%	10 m	AR550
CO_2	0–100 g/m³	1 mg/m³	±2 mg/m³	±2%	±4%	±1%	10 m	AR550
CH_4S	0-200 mg/m³	0.1 mg/m³	±0.2 mg/m³	±2%	±4%	±1%	10 m	AR550
Carbonyl fluoride	0-200 mg/m³	0.1 mg/m³	±0.2 mg/m³	±2%	±4%	±1%	10 m	AR550
Cyanogen	0-200 mg/m³	0.05 mg/m³	±0.1 mg/m³	±2%	±4%	±1%	10 m	AR550
Dimethyl amine	0-200 mg/m³	0.1 mg/m³	±0.2 mg/m³	±2%	±4%	±1%	10 m	AR550
Dimethyl ether	0-200 mg/m³	0.1 mg/m³	±0.2 mg/m³	±2%	±4%	±1%	10 m	AR550
Dimethyl sulfate	0-200 mg/m³	0.1 mg/m³	±0.2 mg/m³	±2%	±4%	±1%	10 m	AR550
Ethane	0-200 mg/m³	0.05 mg/m³	±0.1 mg/m³	±2%	±4%	±1%	10 m	AR550
Ethanol	0-200 mg/m³	0.05 mg/m³	±0.1 mg/m³	±2%	±4%	±1%	10 m	AR550
Ethyl acetate	0-200 mg/m³	0.1 mg/m³	±0.2 mg/m³	±2%	±4%	±1%	10 m	AR550
Ethylene	0-200 mg/m³	0.1 mg/m³	±0.2 mg/m³	±2%	±4%	±1%	10 m	AR550
Heptane	0-200 mg/m³	0.1 mg/m³	±0.2 mg/m³	±2%	±4%	±1%	10 m	AR550
Hexane	0-200 mg/m³	0.1 mg/m³	±0.2 mg/m³	±2%	±4%	±1%	10 m	AR550
HBr	0-200 mg/m³	0.1 mg/m³	±0.2 mg/m³	±2%	±4%	±1%	10 m	AR550
HCl	0–100 mg/m³	20 µg/m³	±40 µg/m³	±2%	±4%	±1%	10 m	AR550
HCN	0-200 mg/m³	0.1 mg/m³	±0.2 mg/m³	±2%	±4%	±1%	10 m	AR550
HF	0–10 mg/m³	1 µg/m³	±2 µg/m³	±2%	±4%	±1%	10 m	AR550
Isobutanol	0-200 mg/m³	0.1 mg/m³	±0.2 mg/m³	±2%	±4%	±1%	10 m	AR550
Methane	0–100 mg/m³	0.05 mg/m³	±0.1 mg/m³	±2%	±4%	±1%	10 m	AR550
Methanol	0-2000 mg/m³	0.05 mg/m³	±0.1 mg/m³	±2%	±4%	±1%	10 m	AR550
Methylamine	0-200 mg/m³	0.1 mg/m³	±0.2 mg/m³	±2%	±4%	±1%	10 m	AR550
Nitrobenzene	0-200 mg/m³	0.1 mg/m³	±0.2 mg/m³	±2%	±4%	±1%	10 m	AR550
NH_3	0–100 mg/m³	20 µg/m³	±40 µg/m³	±2%	±4%	±1%	10 m	AR550
Propane	0-200 mg/m³	0.1 mg/m³	±0.2 mg/m³	±2%	±4%	±1%	10 m	AR550
Pyridine	0-200 mg/m³	0.1 mg/m³	±0.2 mg/m³	±2%	±4%	±1%	10 m	AR550
Silane	0-200 mg/m³	0.1 mg/m³	±0.2 mg/m³	±2%	±4%	±1%	10 m	AR550
Vinyl acetate	0-200 mg/m³	0.1 mg/m³	±0.2 mg/m³	±2%	±4%	±1%	10 m	AR550

AIR QUALITY MONITORING

Street

Mobile

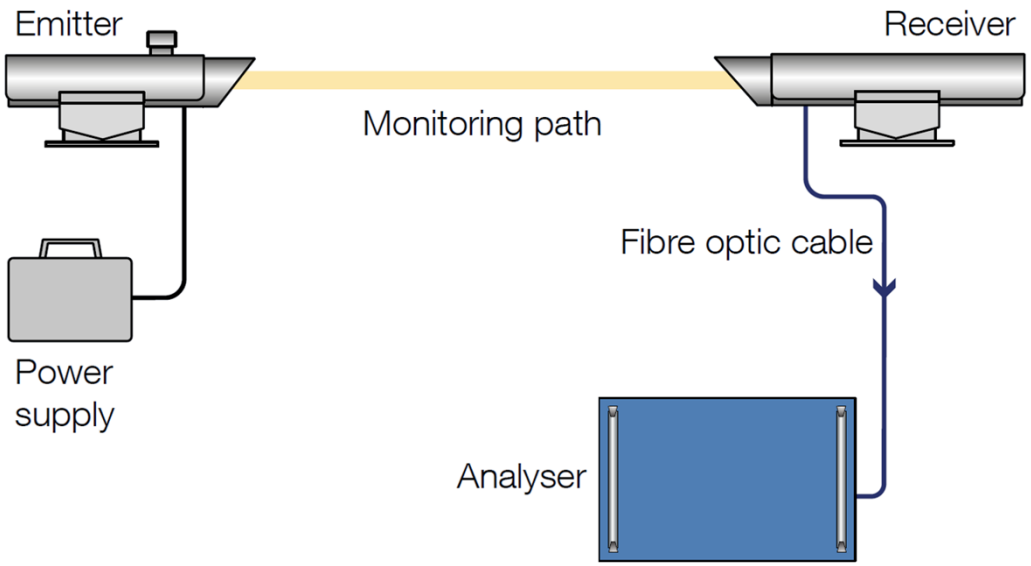
City

Background

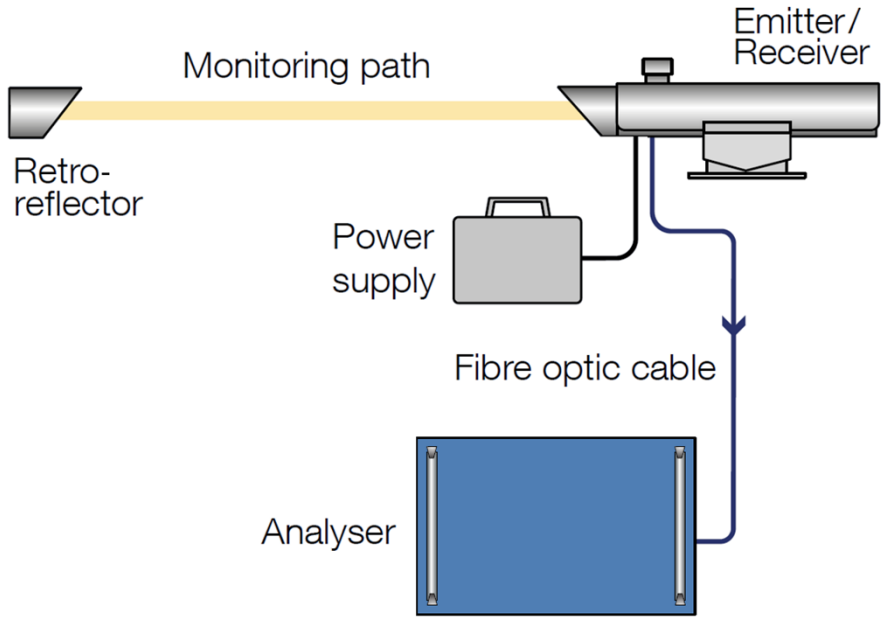
Industries

Airports

Classic System Configuration

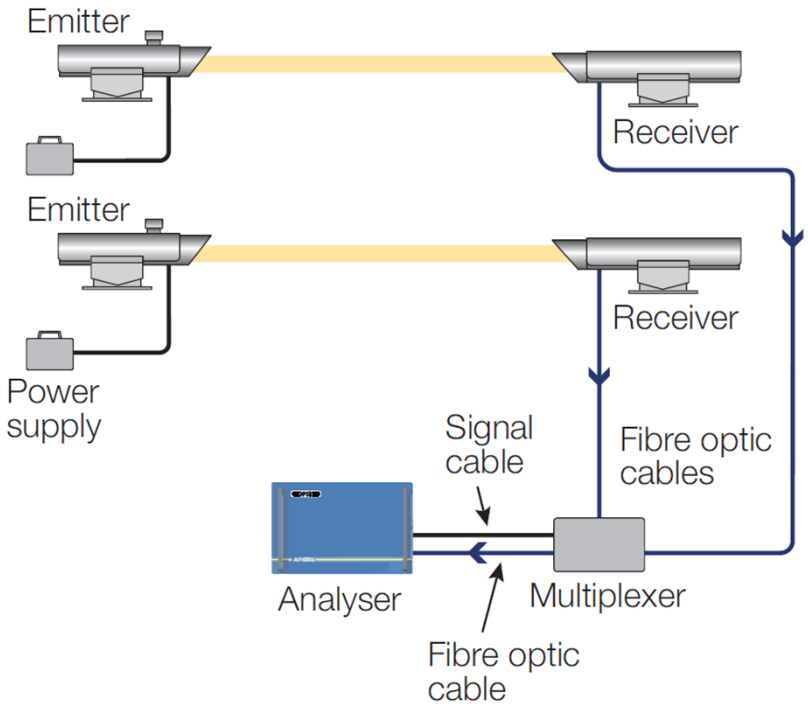


“One-End” Alternative

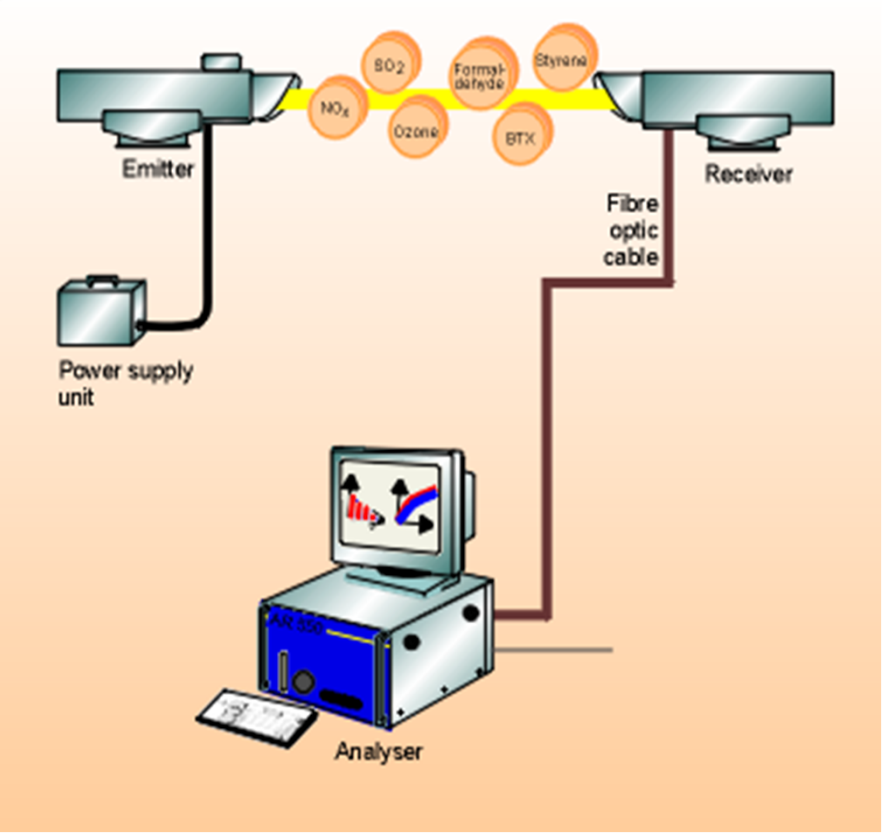


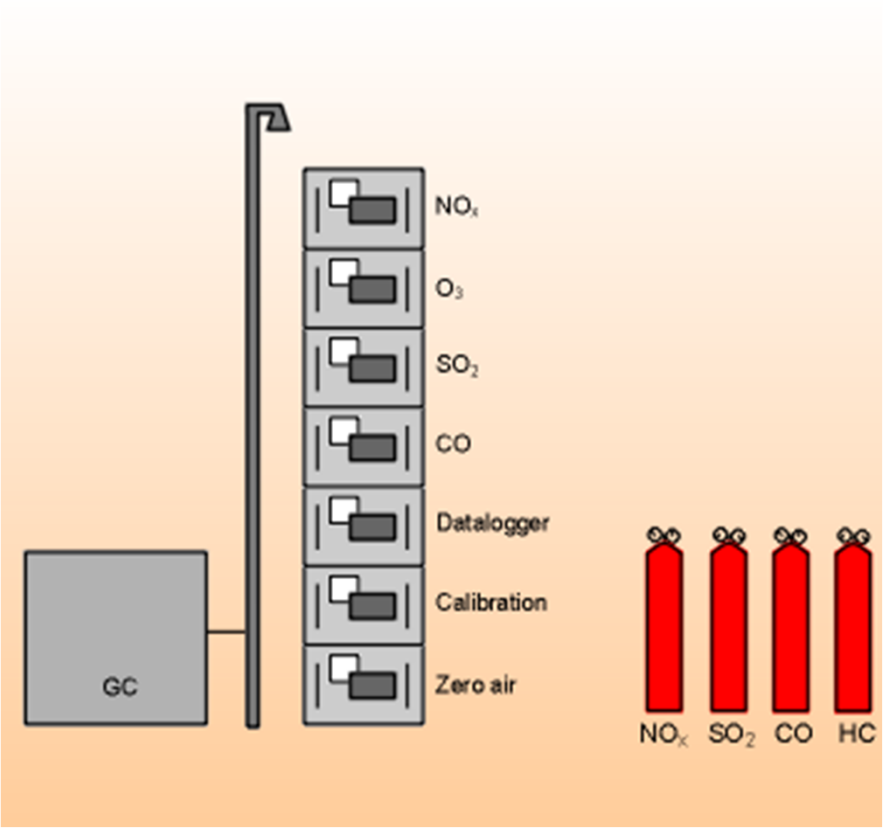
Multiplexers

- One analyser, multiple monitoring paths
- Cost-efficient
- Penalty: total cycle time



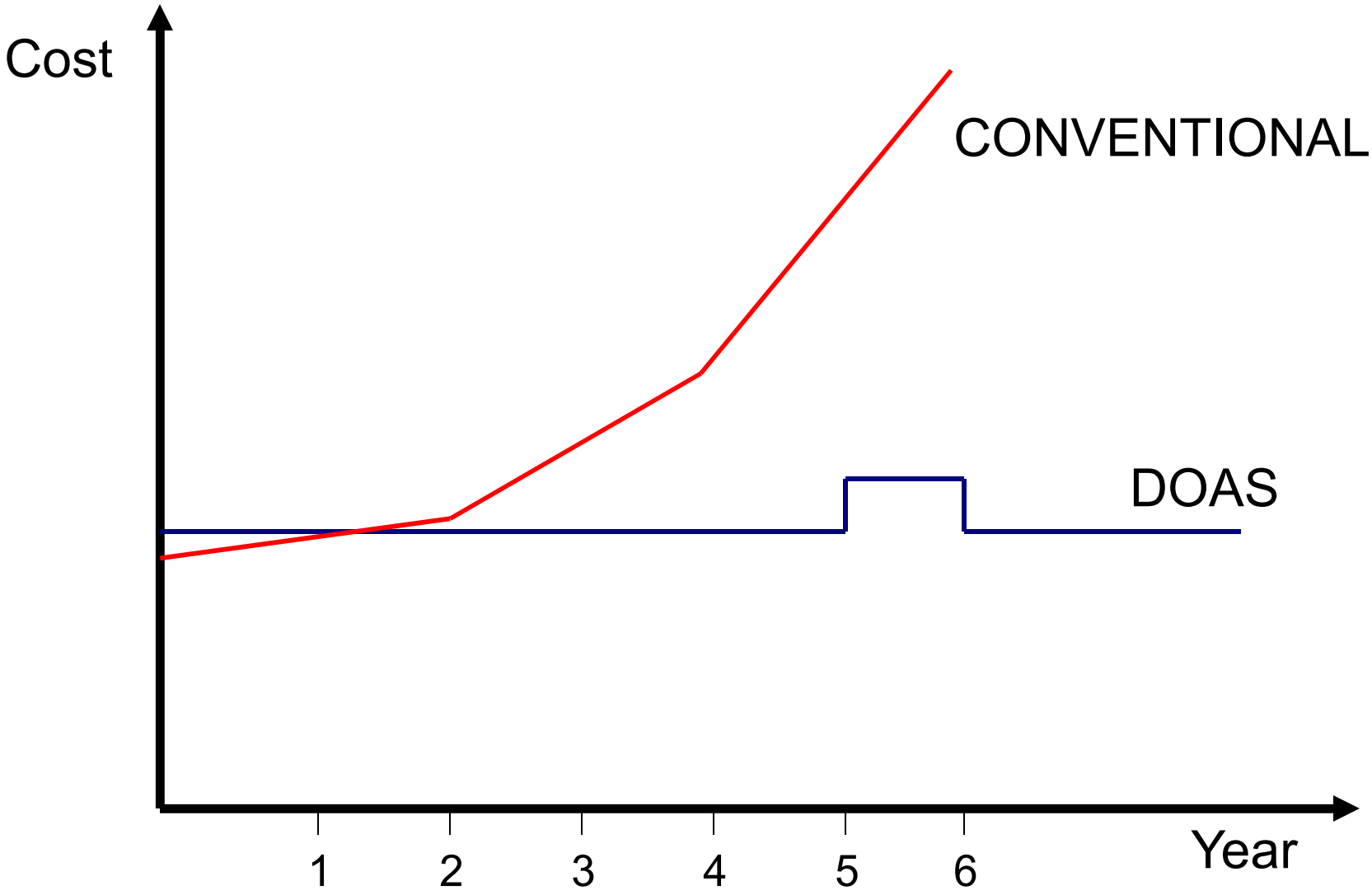
OPSIS vs Conventional Analysers



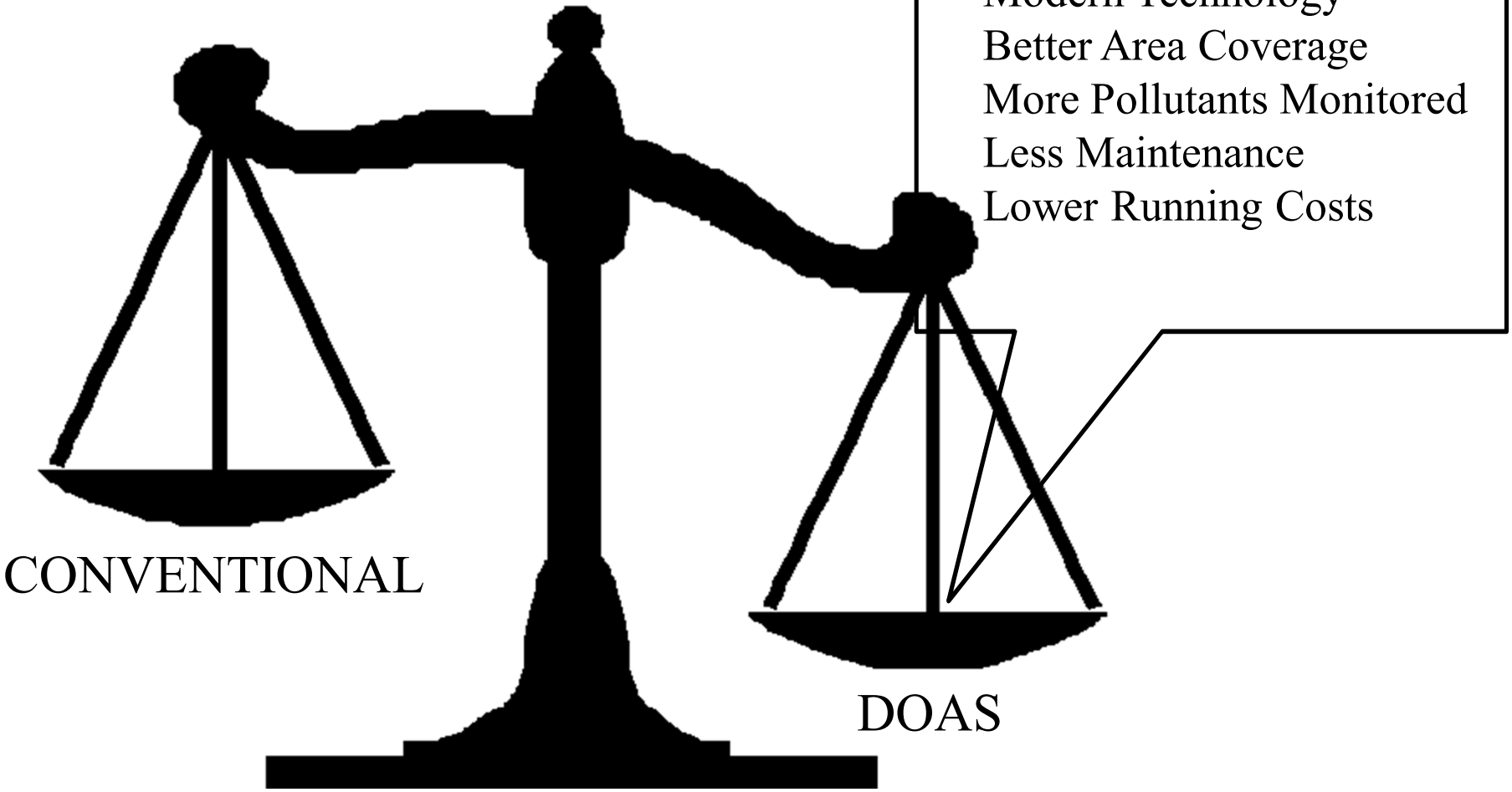


More pollutants, Higher Data Capture, Less maintenance !

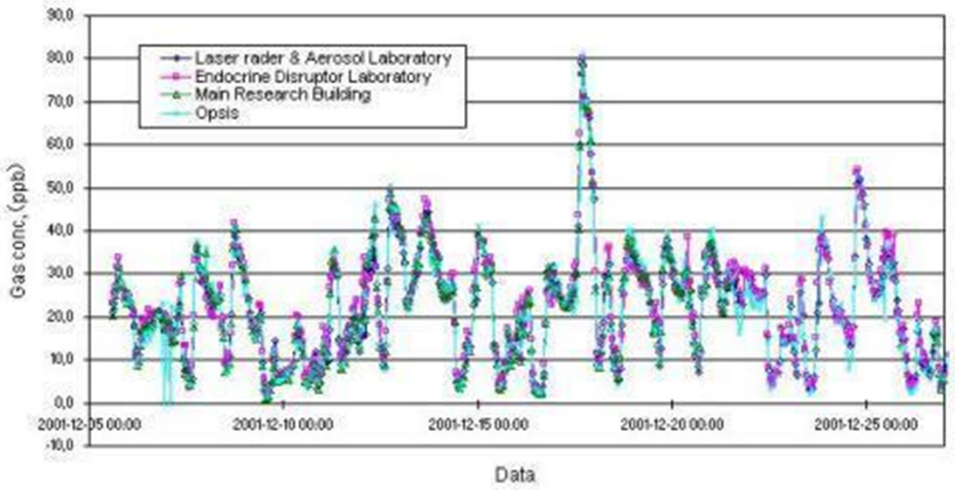
COST OF OWNERSHIP



An obvious choice!



TESTED AND APPROVED



TÜV Rheinland

mCERTS
THE ENVIRONMENT AGENCY'S MONITORING CERTIFICATION SCHEME

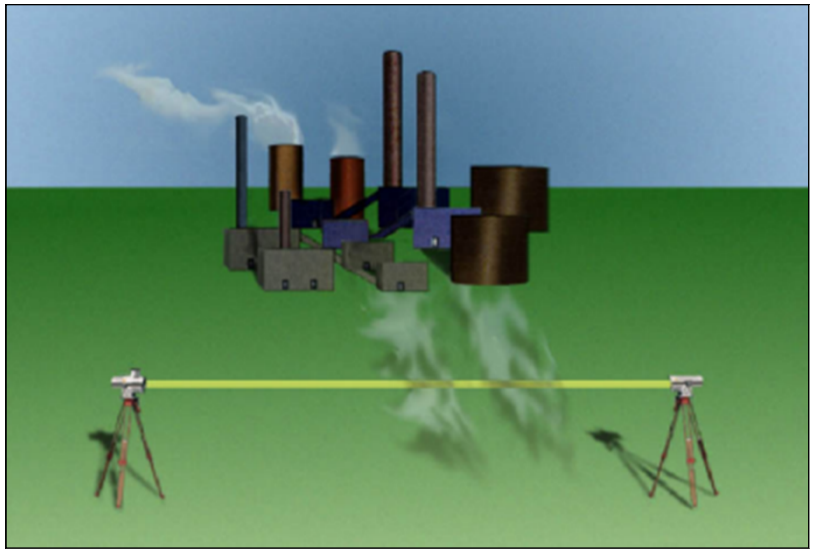
EPA United States Environmental Protection Agency
"...to protect human health and to safeguard the natural environment..."

中华人民共和国
计量器具型式批准证书

Fence-line Applications

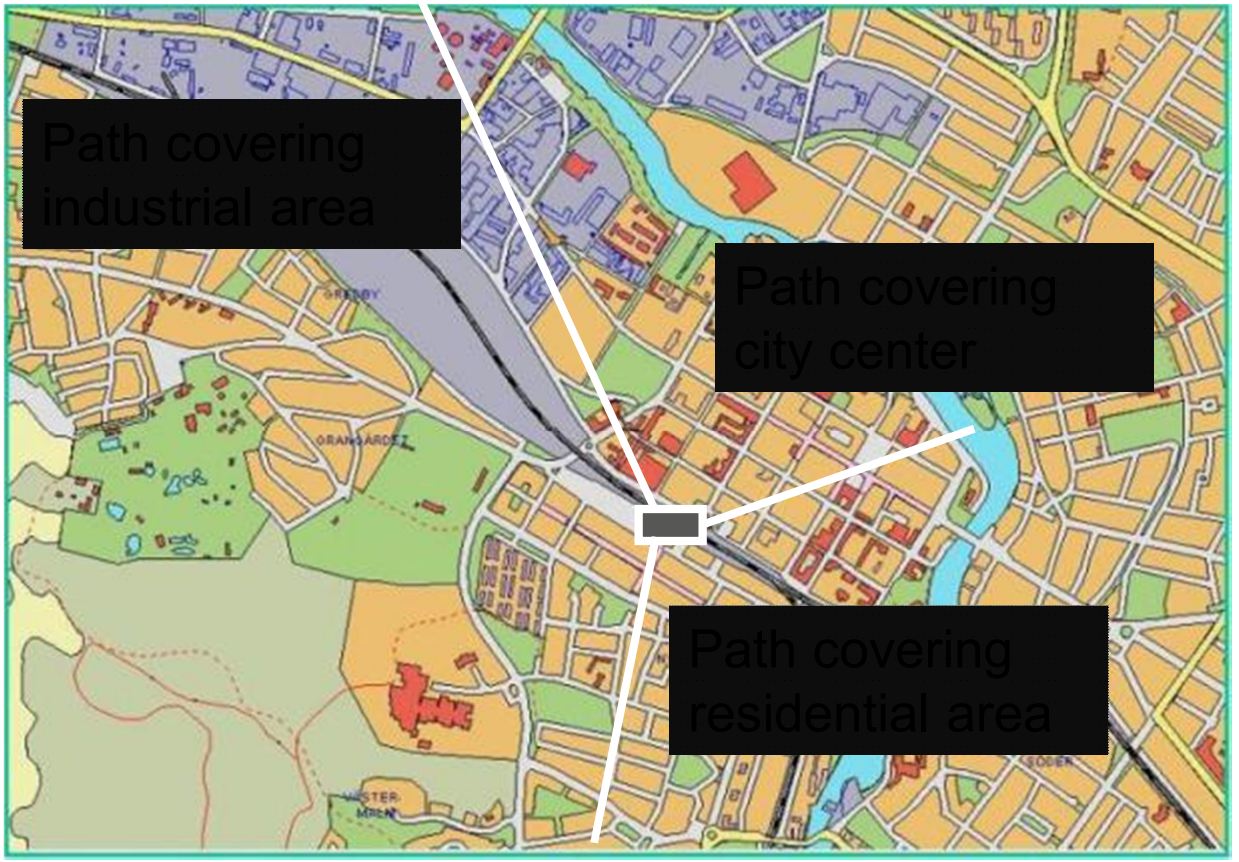
The Fence-line Monitoring Concept

- Three functions in one package:
  - Monitoring Air Quality for compliance with standards/guidelines
  - Monitoring fugitive industrial and stack emissions
  - Providing a fast and sensitive gas alarm system



MULTIPLE PATH MONITORING

- Superior Area Coverage
- More information than with single point or path
- Cost effective



Features – Fence-line

- Provides useful information on general air quality, but also on specific industrial fugitive emissions
- It can locate sources of specific emissions
- Provides useful information for Air Quality Management and ISO 14000 compliance
- Will give extensive information on export and import of gaseous compounds to and from neighbouring areas
- Provides alarms in case of gas leaks or accidental releases.

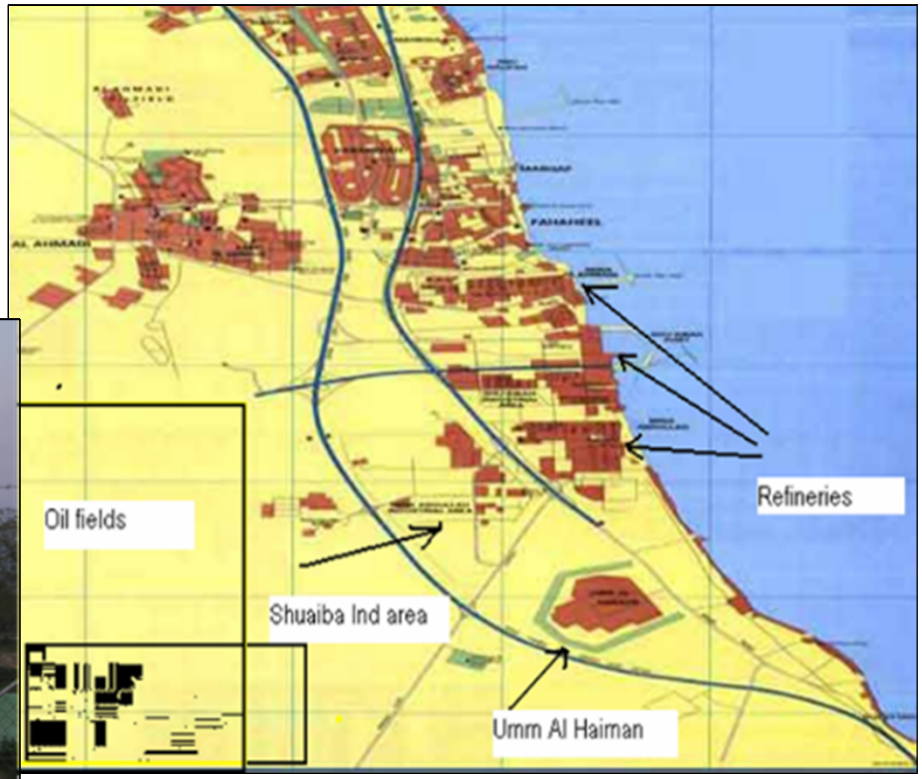
Application Examples

Example , Sterlite Industries, India

Copper Smelter with Acid Plants etc , two analysers with total four monitoring paths for NO_2 and SO_2

Example: Umm Al Haiman, Kuwait

Fence-line monitoring using
two DOAS analysers with
two monitoring paths each

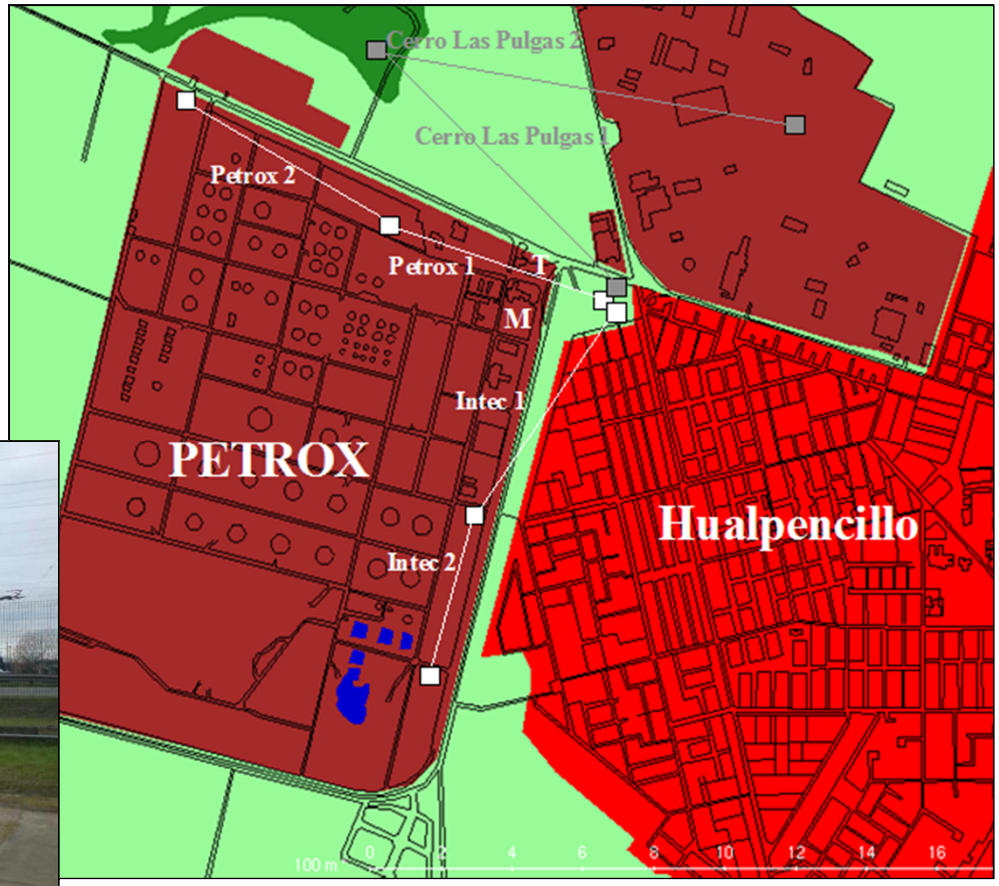


Example: Stara Zagora, Bulgaria

Fence-line monitoring using three DOAS analysers with three monitoring paths each

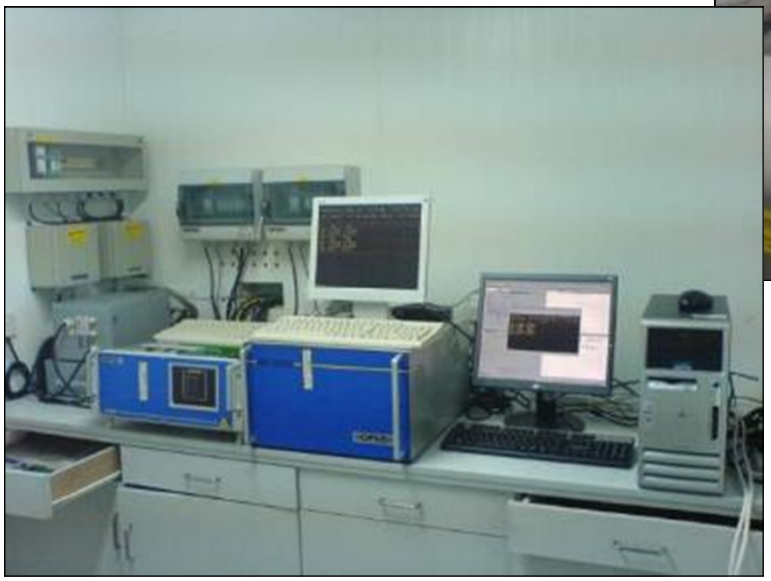
Example: Petrox, Chile

Fence-line monitoring around the refinery using 2 x 2 DOAS paths



Example: ALBA, Bahrain

Fence-line monitoring using one DOAS analyser with two monitoring paths and one LD500 with two monitoring paths

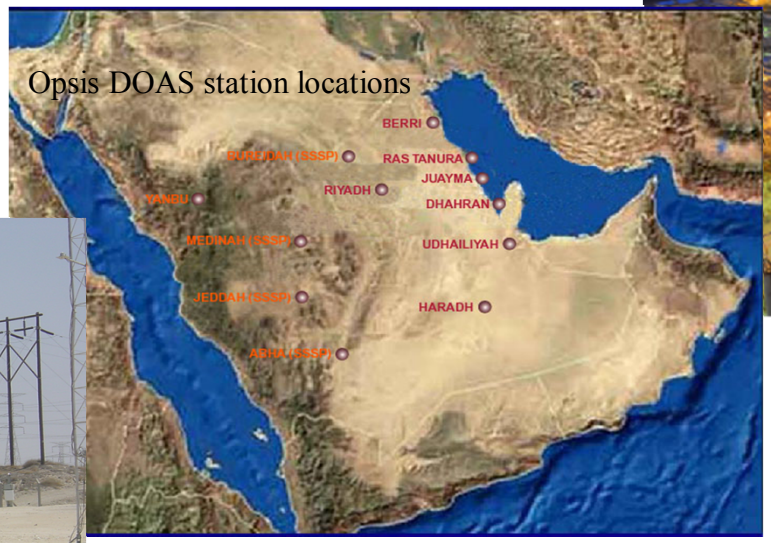


Example: Porto Marghera, Venice, Italy

Fence-line monitoring using three DOAS analysers with two measurement paths each in and around the port and refinery area

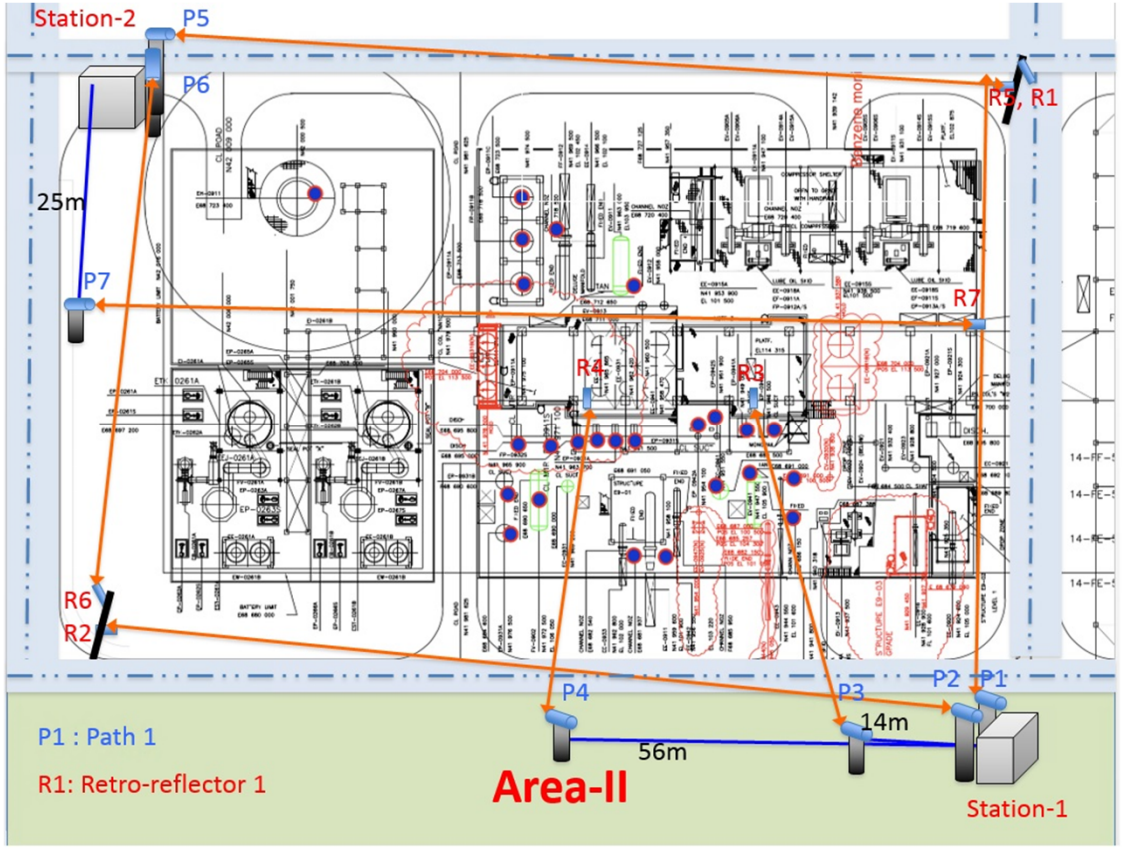
Example, Saudi Aramco, Saudi Arabia

Opsis DOAS fence line monitoring installed at
twelve different production and storage fascilities



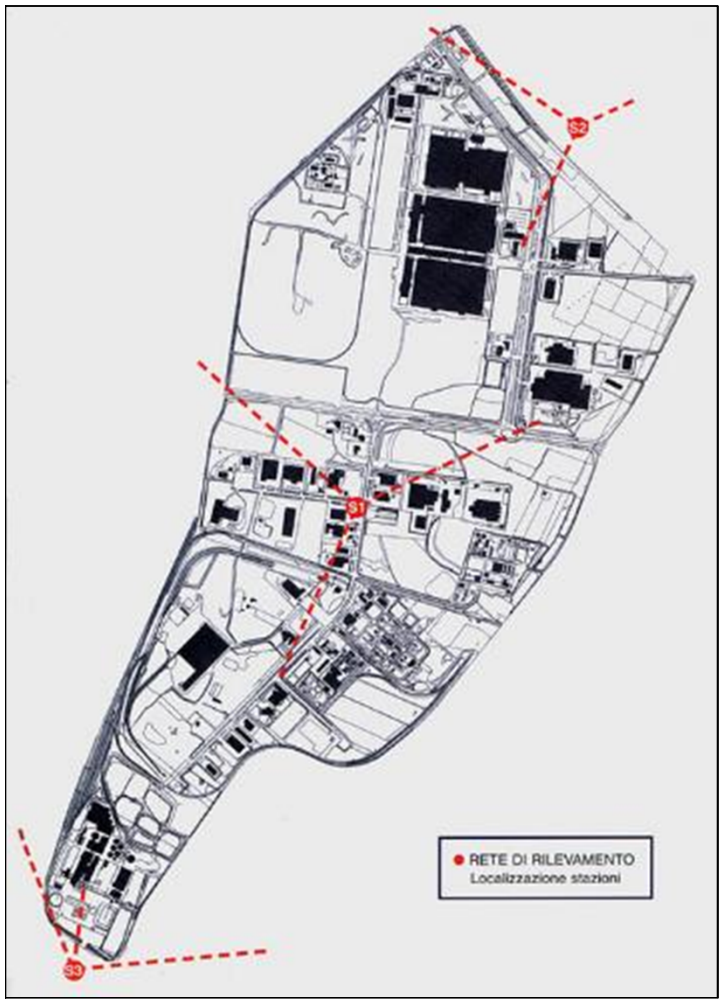
Example, SABIC/Petrokemya ,Al-Jubail, Saudi Arabia

Monitoring of Benzene for alarm purpose.Two systems with totally 7 measurement paths



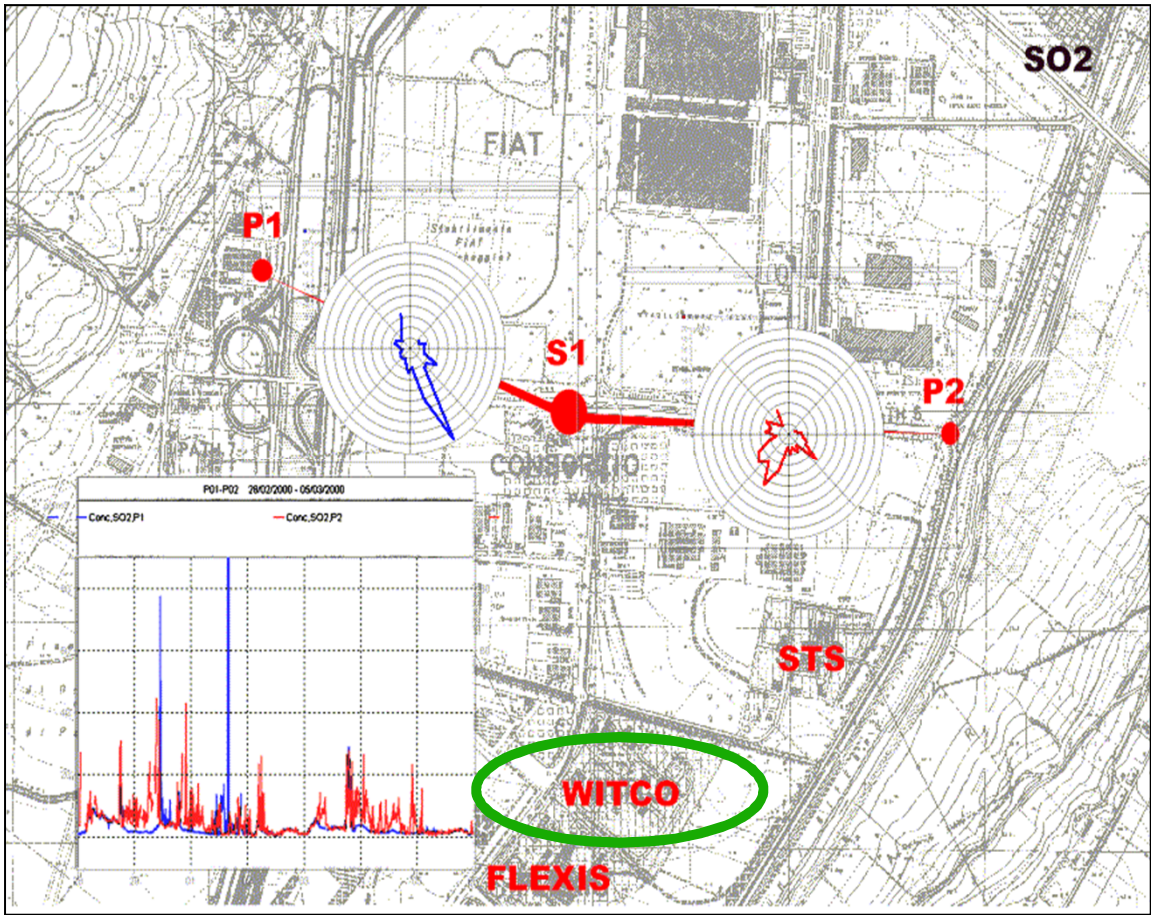
Example: Biferno, Italy

Fence-line monitoring using three DOAS analysers with three monitoring paths each, in and around the industrial park



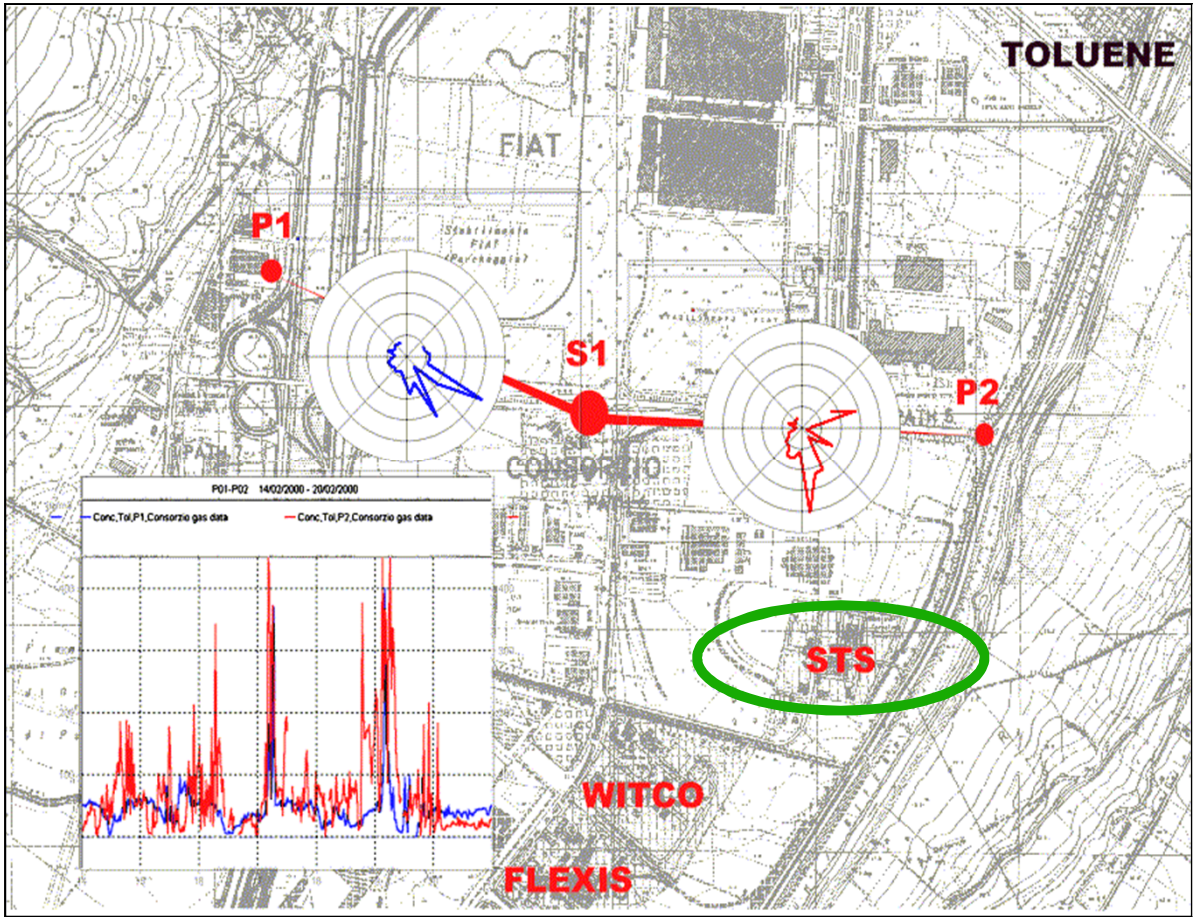
Example of Practical Achievements

The major source of SO_2 could be identified as ”WITCO” using Breuer diagram with SO_2 and wind information

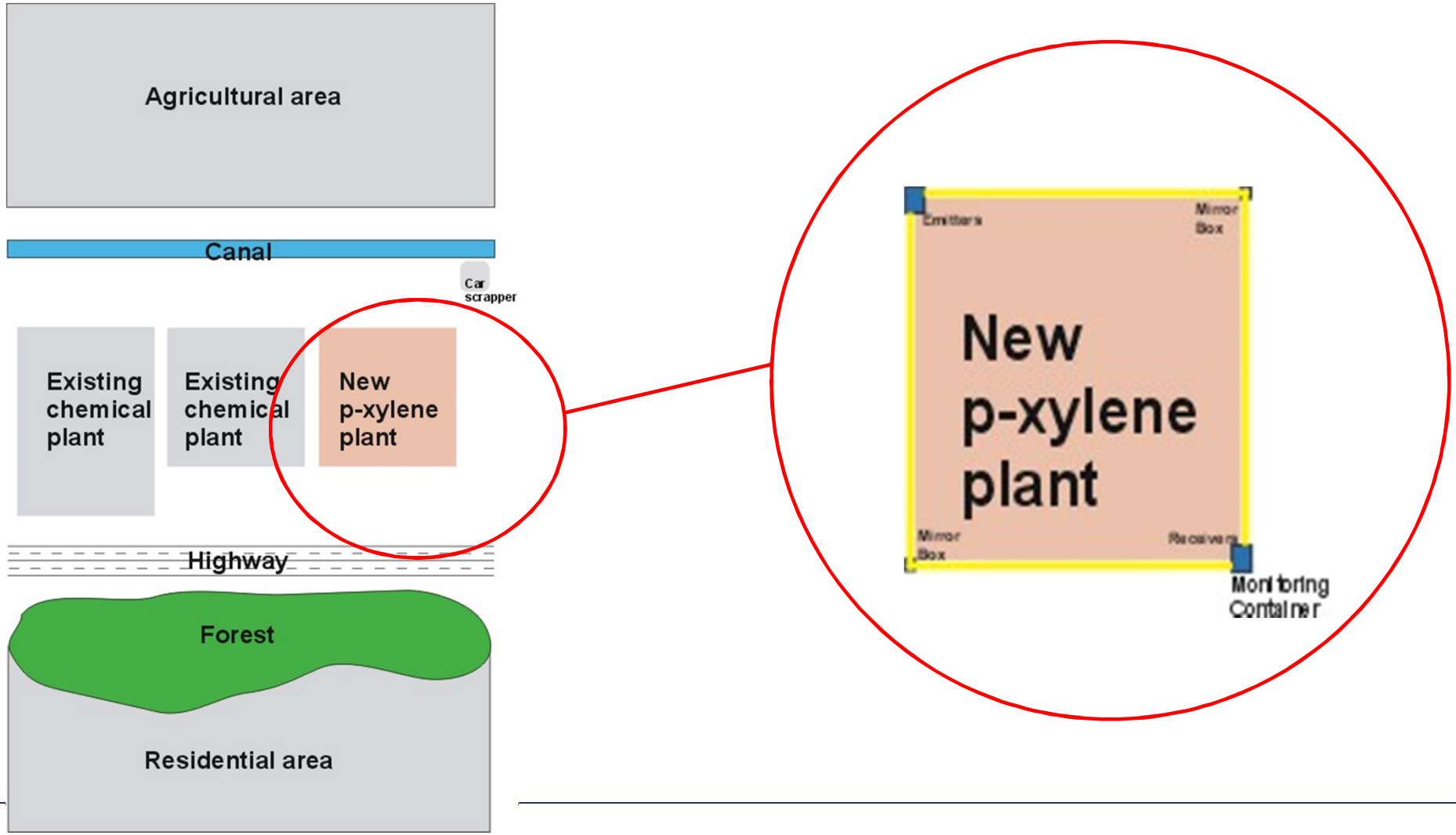


Example of Practical Achievements

The major source of toluene could be identified as ”STS” using Breuer diagram with toluene and wind information



BP Belgium


Agricultural area
Canal
Car scrapper
Existing chemical plant
Existing chemical plant
New p-xylene plant
Highway
Forest
Residential area
New p-xylene plant
Mirror Box
Mirror Box
Monitoring Container

US EPA Air Enforcement Division (AED)

- A federal division being the ”Environmental Police”
- Using Opsis DOAS for more than 15 years
- Used at over 100 industrial locations
- Results used to verify that industries comply with regulations
- Results are used in legal cases
- Info: https://clu-in.org/programs/21m2/openpath/uv-doas/

Examples in Thailand….

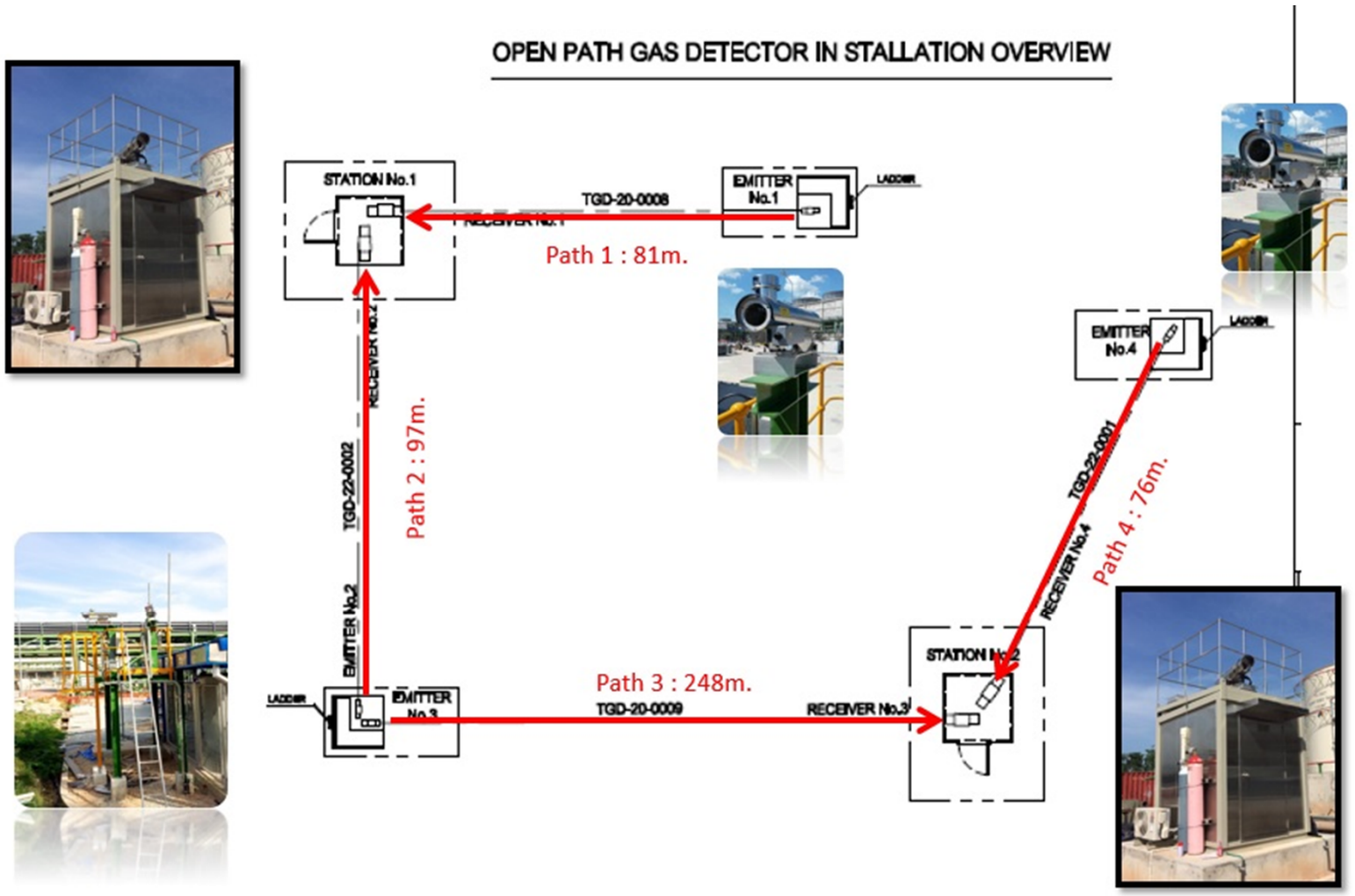
IEAT, Map Tha Phut
3 stations with AR500 UV-DOAS calibrated for:SO_2, NO_2, O_3,benzene, toluene,formaldehyde, phenol, styrene,acetaldehyde, carbon disulphide, and phosgene

Examples in Thailand….

IRPC, Rayong, monitoring chlorine, benzene, toluene, xylenes and ammonia

Examples in Thailand….

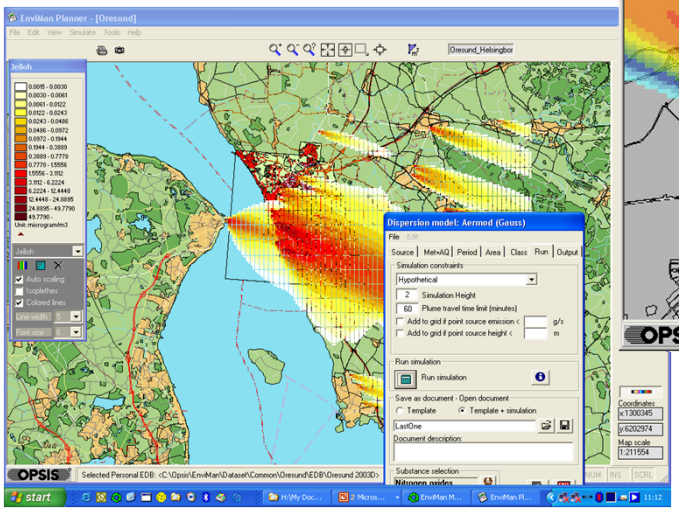
PTT Phenol , monitoring benzene with 2 analysers and 4 monitoring paths



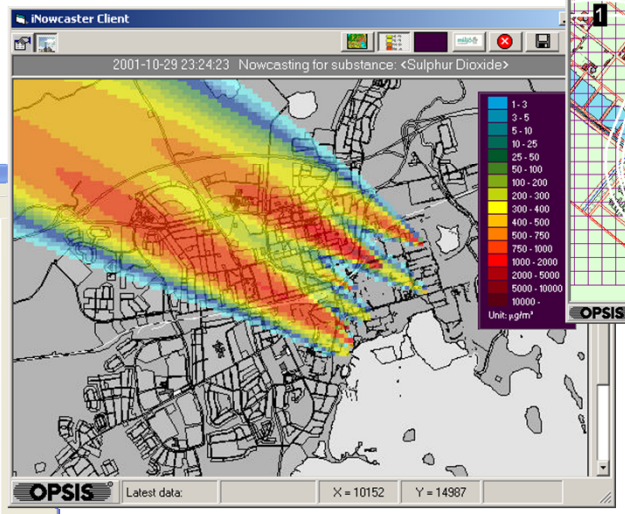
Other tools for understanding pollution in Industrial areas

Opsis Enviman Air Quality Management Software, for …

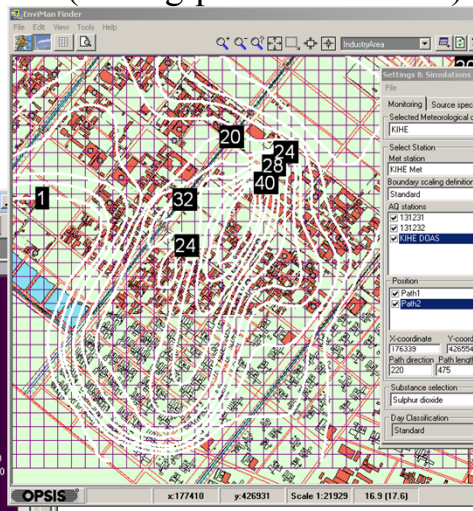
Multiple source dispersion modelling



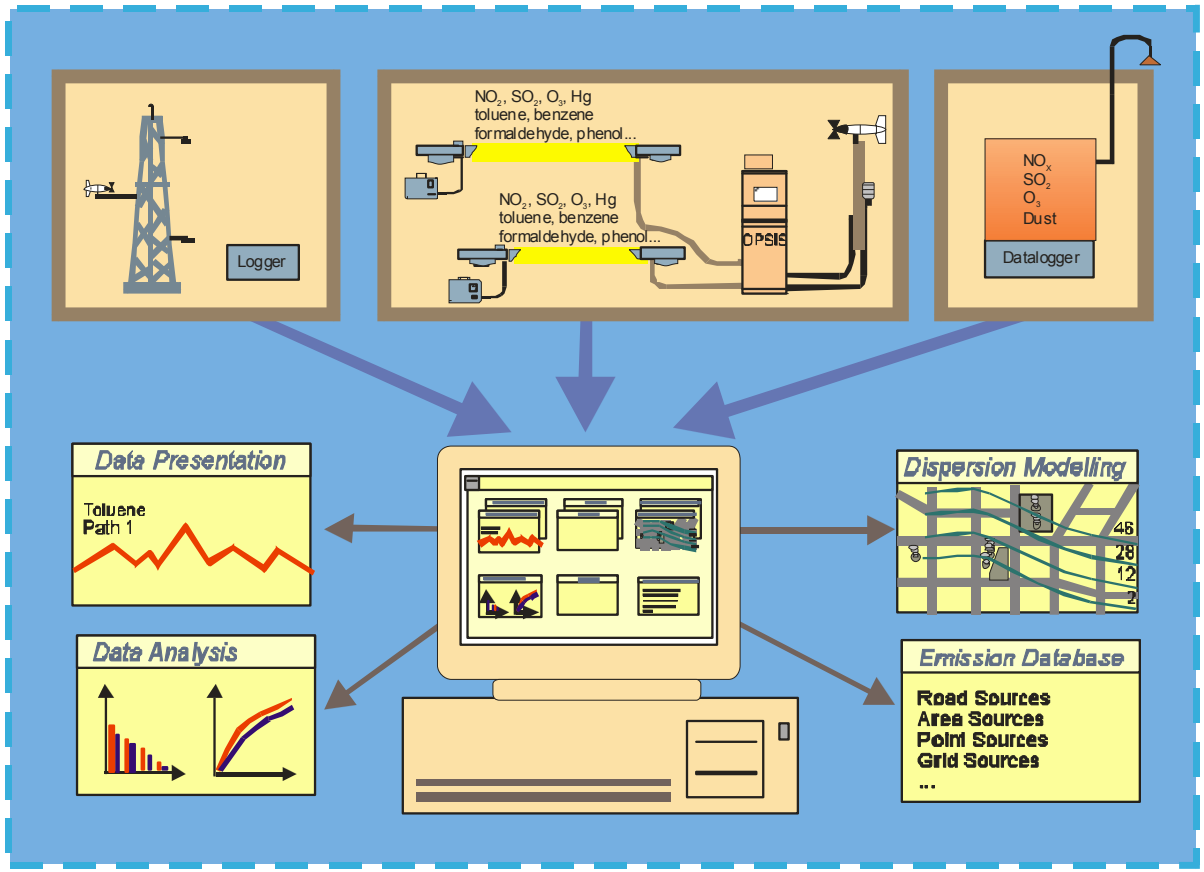
Real time dispersion modelling



Receptor dispersion model (finding pollution sources)



A total monitoring and management solution for industries



Conclusions

Modern technologies such as open path DOAS monitoring system can provide important information on the pollution situation in and around industrial estates, such as:

- How residential areas are affected by specific industrial emissions
- Import and export of pollution in the area
- Locations of the most significant sources of pollution
- Concentrations of gases to be compared with guidelines and health limits
- A database for future planning and decision-making

OPSIS DOAS Benefits

- No sampling system, pumps, filters or scrubbers
- Low maintenance and operational costs
- Multiple gas capability
- Multiple path capability
- Superior area coverage
- High performance
- Integrated signal handling system
- Long life time
- Internationally approved

OPSIS AQM Product Approvals

U.S. EPA

The OPSIS system is designated as equivalent reference method

- SO_2, NO_2, O_3
- US ETV verified for Benzene, NO, NH3

Gosstandard, Russia

- SO_2
- NO
- NO_2
- O_3
- H_2S
- NH_3
- CO
- Cl_2
- HCl
- Styrene
- Benzene
- Toluene
- Phenol
- Formaldehyde
- HF
- CH_4

MCERTS, UK

- SO_2
- NO_2
- O_3
- Benzene
- PM10
- PM2.5

TÜV, Germany

- SO_2
- NO_2
- O_3
- Benzene
- PM10
- PM2.5

China EPA

NIER, Korea

EPA, Kuwait

Etc..

New US EPA Regulation for refineries: Fence line monitoring of Benze

- The rule becomes effective on Feb. 1, 2016 and existing sources have to comply by Feb. 1, 2019
- EPA requires industries to reduce emissions from flares, storage tanks, delayed coking units, and implement fence-line monitoring of benzene
- Limit value is 9 ug/m3 !
- EPA concluded that only passive samplers and/or UV-DOAS can be used !

- http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OAR-2010-0682-0700

OPSIS – Complete AQM Solutions

Data presentation and reporting, modelling

AQM stations

Dust/PM10/PM2.5

Meteorological masts

DOAS open path systems

Public information

www.opsis.se