CHARM®
Laser Based Aerial Leak Detection for Gas Pipelines
Differential Absorption LIDAR

System emits laser pulses with two different wavelengths:

- $\lambda_{\text{on}}$
  Measurement wavelength: light is absorbed by methane

- $\lambda_{\text{off}}$
  Reference wavelength: CH$_4$ is transparent for this wavelength

A difference in the backscatter signal indicates the presence of Methane
Concentration Path Length (CPL) Product [ppm \cdot m]

- Small Dense Gas Plume
  - 1 mm (0.04 inch)
  - $10^6$ ppm
  - 1000 ppm\cdot m

- Gas Layer
  - 5 cm (2 inch)
  - 500 ppm
  - 25 ppm\cdot m

- Medium Size Thin Gas Plume
  - 5 m (16 ft)
  - 5 ppm
  - 25 ppm\cdot m

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Detection Limit vs. Detectable Leak Rate

- System detection limit (given in ppm∙m) depends on few external parameters like:
  - Target (reflectivity, roughness, ...)
  - Methane concentration (only for very high concentrations)
- **System detection limit does not depend on the wind speed**

**BUT**

- Due to the wind the gas emitted by a leak will be diluted
- Higher wind speed requires higher leak rates to obtain detectable gas concentrations
- **Detectable leak rate depends on wind speed**
  - Verification of detectable leak rate requires field test verification under defined conditions
100 measurements / s

pipeline center line

width 7 – 12 m
Navigation

CHARM® - Automatic Beam Guiding

- Differential GPS with worldwide correction service OmniSTAR (via satellite)
- Inertial measurement system to determine the spatial position and movement of the helicopter
- Integrated data base for all pipelines to be monitored
- Real-time-calculation and -control of the laser beam ensure congruence of scan sector and pipeline centerline
Why is pipeline tracking essential?

Flight path without tracking

Scan sector centerline without tracking

Pipeline & tracked scan sector centerline
Downwind Gas Detection?

Pipeline

Real leak position

350 ft

Assumed leak position

200 ft

Real wind (+ 20°)

Assumed wind

Flight path

Gas detection

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Current Helicopter in Use: BO 105

- Helicopter can follow complex pipeline networks much better than fixed wing aircraft
- CHARM® can be installed within 30 min in the helicopter
- EASA-certification for BO 105
- Flight altitude 250 – 500 ft:
  - High sensitivity
  - Visual survey of pipeline swath
- Survey speed: 30 - 40 kn (35 - 45 mph)
- Small crew: pilot and system operator
- Working on adaptation for different helicopters (EC 135, MD 900)
- The only remote sensing system with DVGW-certification
Standardization

First technical standard for airborne leak detection worldwide

- Is accepted in most European countries
- Compliance to this standard is a critical success factor in Europe
- Makes different systems comparable
- A customer knows what he gets and must not only rely on marketing stories

Key criteria for compliance

- Reliable gas leak detection under clearly defined conditions
- Sufficient coverage of the pipeline swath with measurements
Standardization: Test scenarios

Test Scenario
"Permeable Surface – rural"

Test Scenario
"Sealed Surface – urban"
Standardization: When is a pipeline survey ok?

Test Scenario
"Permeable Surface – rural"

Test Scenario
"Sealed Surface – urban"

Segment not ok

Segment ok

Valid Spots

Non-valid Spots
Laptop Operator
Gas Detection Example

Enhanced Gas Concentration
ROW-scanning
Pipeline
Flight path
Indication (Overview)

<table>
<thead>
<tr>
<th>Indication</th>
<th>CHARM-No. 1</th>
<th>22.07.2011</th>
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<tbody>
<tr>
<td>Coordinates</td>
<td></td>
<td></td>
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<tr>
<td>Type</td>
<td>Gas release</td>
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<td>Status</td>
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<tr>
<td>Relevance</td>
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<tr>
<td>Methane detection</td>
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<td>no</td>
</tr>
<tr>
<td>Concetr. at surface</td>
<td>ppm / Vol. %</td>
<td></td>
</tr>
<tr>
<td>Concetr. in surface soil</td>
<td>ppm / Vol. %</td>
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</tr>
<tr>
<td>Concetr. after venting</td>
<td>ppm / Vol. %</td>
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<tr>
<td>Repair actions</td>
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<td></td>
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<tr>
<td>Pipeline</td>
<td>tree cavity</td>
<td>subsurface</td>
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<td>Soil condition</td>
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<td>damp</td>
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<tr>
<td>Wind direction (approx.)</td>
<td></td>
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<tr>
<td>Remarks (e.g. valves, other components or pipelines, surrounding area characteristics)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date / Name</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Immediate Messaging

High and very local gas concentration:
• Indication for a dangerous gas release
• Automatic SMS from System to CHARM-team
• Immediate evaluation of local situation
• Alert -> pipeline operator

Example:
• Damage of street cover and valve during street work
• Local gas line
• No repair of gas valve
• Only asphalt burying street cover
CHARM: Experience

- Customer feedback: ~ 75% of the gas indications reported to the customer were related to their pipelines
  - 100% would raise the questions whether some leaks were missed
  - 20% wouldn’t be acceptable for customer
- Certified (DVGW) since 2008
- Survey experience: > 60,000 km
- Active in 8 different European countries
Web – Interface for Customer

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Detectable Leak Size

CHARM: Detectable leak rate: 5 scfh
New Generation of CHARM Technology

- New laser system allows for 1,000 measurements/s instead of 100 measurements/s
- Larger scan sector (up to 25 m) allows for
  - Survey of pipelines with lower geo-data quality
  - Survey of parallel pipelines within the scan sector
- Higher survey speed up to 100 kn
- Can be upgraded for the detection of Propane (LPG-pipelines, Crude oil pipelines)
- 2x better economic performance compared with CHARM 1

New Helicopter: MD 900

- Longer endurance
- More quiet operation
- Additional passenger possible

Schedule

- First flights (with BO 105) during next winter
- Integration in MD 900 2016
The Service Process

1. Pipeline data input from client
   • Conversion from various data formats
   • Data processing for flight planning

2. Planning, implementation of flights, and data collection

3. Data analyzing and reporting
   • Classification of leak indications
   • Verification of leak source
   • Compilation of a client specific report
   • Data processing for integration with client-GIS