Methane Airborne Detection Solution – What is Infrared Imaging Hyperspectral Technology

Infrared Radiation

Electromagnetic radiation (EMR) is emitted by any object according to its temperature. For certain temperatures, the radiation is emitted in the infrared region of the electromagnetic spectrum at wavelengths longer than that of visible light but shorter than microwaves. This process is referred to as thermal emission. In addition, when molecules absorb energy, they can vibrate in specific modes, which can result in the absorption and/or emission of infrared radiation within specific regions (specific wavelengths or wavenumbers) of the electromagnetic spectrum (Figure 1).

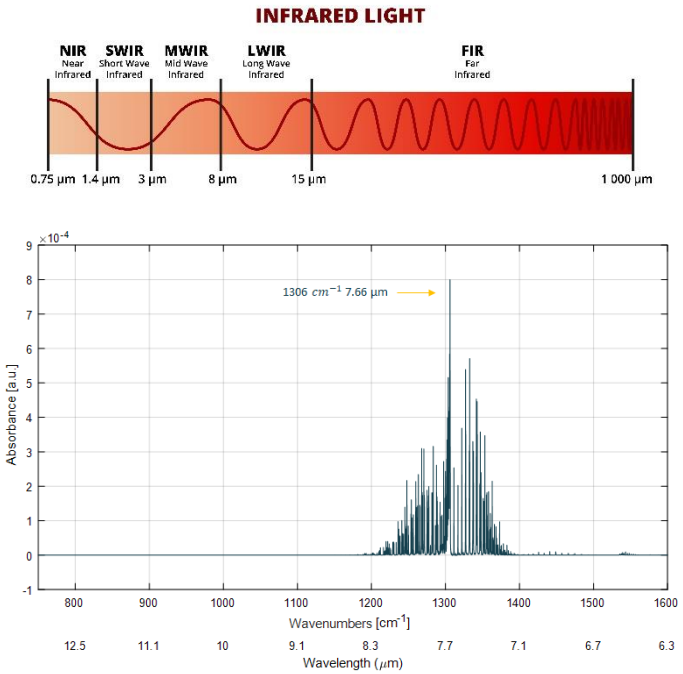

Figure 1. Upper: Spectrum of Infrared Light. Lower: IR spectrum of methane (CH_4) gas

For example, methane gas has a very distinct and unique IR signature (Figure 1). The spectral absorption feature at 1306 cm^{-1} is responsible for scattering infrared heat radiation from the Earth before it can escape to space thus playing a major role in driving climate change.

Imaging Hyperspectral Technology

A broadband infrared camera (responsive from 8 to 12 µm for instance) is capable of detecting such radiation but is incapable of resolving finer details within the IR spectrum. A hyperspectral system on the other hand, decomposes the IR light into a multitude of contiguous spectral bands, similar to visible light spread into its basic colours when passing through a prism. An imaging hyperspectral camera thus creates an image of the scene composed of a complete and detailed spectrum for every pixel in the image. The resulting data product is called a datacube and is illustrated in Figure 3.

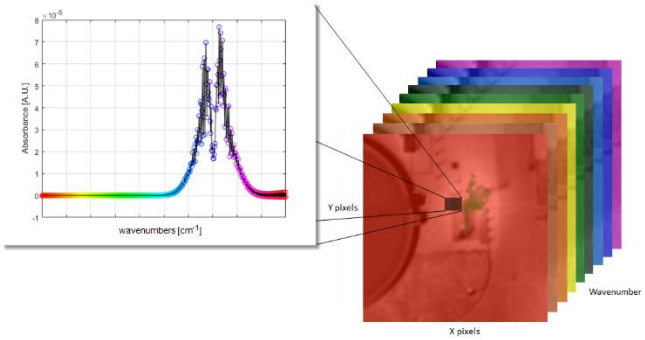

Figure 3. A datacube is composed of a series of IR images at different wavenumbers equally spaced within the bandpass of the camera. Each pixel contains an IR spectrum.

The Hyper-Cam Airborne Mini

Telops has been designing and producing imaging hyperspectral cameras for 20 years now. Its latest downwards-looking long-wavelength infrared (LWIR) hyperspectral camera, the Hyper-Cam Airborne Mini

(Figure 4) is perfectly suited for detecting, identifying and quantifying methane emissions in the upstream and midstream oil and gas sectors. The camera detects the 1306 cm^{-1} (v3) thermal absorption and emission of CH_4.

The Hyper-Cam system is designed in a compact two-unit assembly, the Control & Processing Box and the hyperspectral camera head (refer to Figure 4). This design allows great flexibility in the positioning of system components, facilitating integration into different types of aircraft, from fixed-wing to helicopters. The Hyper-Cam Airborne Mini adapts autonomously for flight conditions and provides automatic and real-time reporting on found methane leaks. It can be flown on a multitude of different platforms and is well adapted for surveying both oil and gas sites and pipelines.

Figure 4. The camera head of the Hyper-Cam Airborne Mini system.

Advantages of Imaging Hyperspectral Technology

The fact that the Hyper-Cam Airborne Mini records a complete LWIR spectrum makes it possible to not only detect methane, but any substance having a spectral signature in the bandpass of the sensor like hydrocarbons and several organic volatile compounds (VOCs) with the same acquired dataset. Figure 5 provides an example of a simultaneous airborne detection of 3 different compounds (acetone, ethylene and methanol).

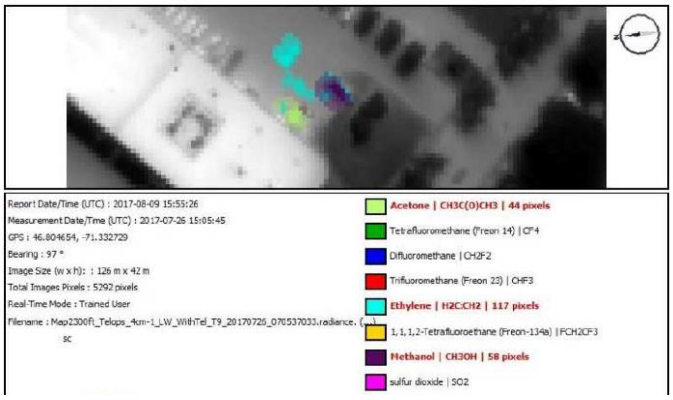

Figure 5. Simultaneous airborne detection of multiple substances, acetone (green), ethylene (cyan) and methanol (purple).

Because the Hyper-Cam Airborne Mini operates in the LWIR band, it does not directly rely on sunlight illumination, so nighttime operation is possible by exploiting radiative ground cooling under clear-sky conditions. The passive nature of the hyperspectral system (in contrast to an active system relying on the reflection of an emitted laser signal for instance) brings excellent detection performance over highly IR reflective or absorbing ground surfaces like snow or water. Figure 6 shows a methane plume detection over snow covered ground in Alberta, Canada.

Figure 6. Left: Methane detection over snow covered region. Detected methane plume is shown in green. Right: Corresponding visible imagery from the 12 mega pixels camera aboard the Hyper-Cam Airborne Mini.