NEW ERA TECHNOLOGY, INC.

The Complete Aerial Surveying, Remote Sensing, and Reporting Solution for the Oil, Gas, and Product Energy Sector

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From the Desk of the President

Future of Leak Indication Technology

In the last newsletter I wrote about the next generation of leak indication sensor that New Era was developing and the process that we are following. In this issue I would like to update based on the steps outlined in the last issue.

1. An extended design phase with each step receiving several reviews by each of the disciplines involved in the process.

The design and review phase of the project has been completed after several revisions during the process to assure performance and maintenance objectives.

2. Once a design has been tentatively agreed to by the various disciplines it is then submitted for analysis by an outside third party for potential pitfalls.

During the design phase several concerns were raised since this new unit would be flown in both fixed wing and helicopter platforms. The design was sent to an outside analysis consultant to review and provide recommendations on any findings that would impact performance and durability of the equipment.

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Notes from the Scientific Laboratory

Remote Sensing Technology-Past and Present

Hyperspectral

Hyperspectral remote sensing is a broad term that essentially means the indication of gas using spectroscopic data.

Hyperspectral measurements are typically made using an instrument known as a Fourier Transform Spectrometer (FTS). An FTS is based on an instrument known as a Michelson Interferometer (MI), shown in ***Figure 3***.

Incoming monochromatic light (i.e. laser) is split onto two optical paths using a half-silvered mirror. The light is reflected off separate mirrors and recombined again at the half-silvered mirror. The recombined light from the two paths produces an interference pattern, which can be used to very accurately measure the wavelength of the incoming light.

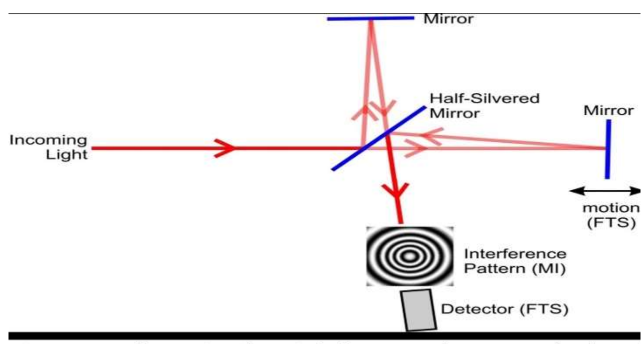

Figure 3: Schematic of a Michelson Interferometer (MI) and Fourier Transform Interferometer (FTS).

An FTS uses the same basic principles as an MI, except (1) instead of laser light as an input it uses continuous spectrum light, (2) one (or both) of the reflecting mirrors is scanned back and forth, and (3) the interference signal is measured by a detector (as also shown in ***Figure 3***). Measurements of the interference signal are made as a function of the position of the scanning mirror, and a spectrum of the incoming light can be determined by performing an inverse Fourier transform on the measured signals.

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3. Once any identified potential difficulties are resolved, it is resubmitted for further analysis to ensure the potential risks have been resolved.

There was an issue that was identified and further study was conducted with the issue being resolved.

4. Prior to the first prototype being assembled each of the subsystems will be assembled and tested to be assured they are functioning as expected.

This is where we are at this time. Some of the subsystems have been completed and tested to our expectations for performance. Two of the subsystems are being proven out as this newsletter goes to press. It is expected that the final subsystems will be completed with the proving out process by the middle of July.

5. Once all the subsystems are qualified then the complete prototype unit will be assembled and tested.

At the end of July the final assembly will be put together and bench tested and analysis of the performance of the assembled will be done.

6. After the completed unit has passed the laboratory testing it will then be installed in the test aircraft for trial testing under real world conditions.

We are currently scheduling the aircraft to be available and ready for the installation of the new sensor in early August.

Notes from the Laboratory

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In the last couple of decades, there have been huge advances in the technology of imaging Fourier Transform Spectroscopy (iFTS). This technology has driven a revolution in remote sensing. iFTSs provide broadband spectral measurements while maintaining spatial information (i.e. imaging), and can be used to extract a multitude of information from a single spectral measurement.

iFTSs are incredibly powerful instruments that are now being used in many remote sensing applications. Their main advantage is that their wide spectral measurements allow them to measure many things at one time (for example, measure more than one gas at a time over a wide spatial area). However, they have not made much inroads into the pipeline leak indications market.

This is because although they can measure a wide spectrum, they have lower SNR (which results in lower sensitivity) and the scanning of the mirror takes time (which introduces noise with a rapidly changing FOV as is the case with airborne remote sensing of pipeline leaks). Like FLIR, iFTS is better suited to static measurements.

Advantages:

- Provides images of the plume
- Can identify the source of the leak

Disadvantages:

- Not ideal for airborne platforms
- Not very sensitive
- Expensive (but has become much cheaper over time)

In general, airborne nadir-viewing hyperspectral instruments do not have the SNR to detect the presence of small concentrations of leaked hydrocarbon gasses. Instead, most attempts to detect pipeline leaks from hyperspectral data involve not the indication of the gas, but the indication of dead and/or distressed vegetation at the sources of the leak. These measurements are performed in the visible and near infrared, where the signal levels are much higher. However, there are many, many possible causes to distressed or dead vegetation that have nothing to do with pipeline leaks.

Differential Absorption Lidar (DIAL)

One commercially successful technique for detecting pipeline leaks is a technology known as Differential Absorption Lidar (DIAL). DIAL is an active remote sensing system in which pulses of light are directed at a target (in this case, the surface). Light that is reflected back to the instrument is collected by a telescope and measured by a detector. If the wavelength of the laser light is on an absorption line of a gas (e.g. methane), then some of the returned energy will be absorbed if that gas is present in the FOV of the instrument (see ***Figure 4***).

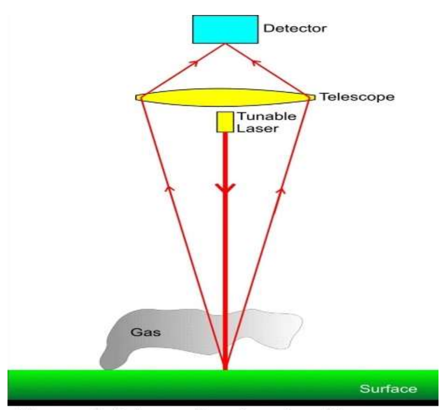

Figure 4 Schematic showing the principles of Differential Absorption Lidar (DIAL).

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Notes from the Laboratory

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In the case of airborne remote sensing of gas leaks, it is impossible to know whether any reduction in the detected signal is due to gas absorption or a change in the reflectivity of the surface. To remove this uncertainty, the laser wavelength is switched between two close wavelengths with each laser pulse. The wavelengths are chosen such that one is located on a strong absorption line of methane (λ_{on}) and the other is off the line (λ_{off}). In addition, given the closeness of the wavelengths, the surface reflectivity is unlikely to be very different. To first order, any "differential" in the detected signals between the wavelength pulses is due to absorption by methane. The principles of an airborne DIAL measurement are shown in ***Figure 5***.

DIAL systems are not inherently imaging, but spatial information about a leak can be determined by scanning the source (and telescope).

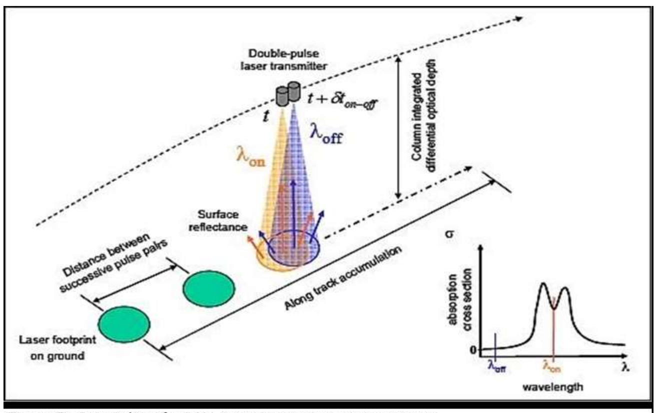

Figure 5: Principles of a DIAL remote sensing measurement.

https://directory.eoportal.org/web/eoportal/airborne-sensors/charm

This adds a mechanical mechanism to the system, usually a 45° mirror mounted on a stepper motor. ***Figure 6*** shows the modelled scanning pattern for a DIAL remote sensing system.

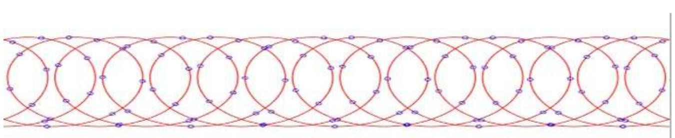

Figure 6: Modelled scanning pattern for a DIAL system

The indication systems of DIAL sensors are usually simple radiometers with telescope inputs. To reduce the noise induced by varying background radiation within the radiometer passband, they are tuned to AC sampling at the frequency of the pulses.

In addition, to minimize noise induced by varying surface reflectivity and the fact that the on-line and off-line laser pulses are not simultaneous, the lasers are pulsed as rapidly as possible. DIAL remote sensing systems were first developed for (and have mainly been employed as) stationary "fence-top" systems.

In this configuration the DIAL system is "looking" horizontally at a retro-reflecting target or mirror in the distance. In this configuration, the DIAL system measures the amount of gas between the system and the retro-reflector (which may be over a kilometer away). Also, because of the non-variable high reflectivity of the retro-reflector, high SNR can be achieved making this configuration very sensitive and accurate

In airborne nadir remote sensing configurations DIAL systems are limited by significantly reduced and highly varying surface reflectivity. To counter these problems, most DIAL systems have employed high-power 1.65 µm lasers; even though the absorptivity of methane at 1.65 µm is much lower than at 3.3 µm (see **Figure 1**). This is due to the fact that lasers at these wavelengths (1.65 µm) are much more powerful, tunable (i.e. vary wavelength), pulsable, and much cheaper than 3.3 µm lasers (where the highest sensitivity to methane may be achieved).

The main limiting factor to the sensitivity of airborne DIAL systems is the fact that the measurements of the on and off absorption peaks (λ_{on} versus λ_{off}) are separated in time (see **Figure 5**). This means that as the aircraft moves forward the surface where λ_{on} is detected is different from where λ_{off} is detected. As a result, surface variability convolves noise into the differential absorption signal, limiting the accuracy of the measurement. This source of noise can be reduced by increasing the frequency of the on-off pulses, but doing so reduces the detected signal levels, which also limits sensitivity.

One final consideration is the operational requirements of airborne DIAL systems. These systems often fly at an altitude of ≈100 to 150 ft. On any aircraft, this is a very dangerous altitude, as engine power loss almost always results in fatalities.

Advantages:

- Can be very sensitive to gas leaks
- Can operate in cloudy conditions

Disadvantages:

- Not truly imaging, hard to identify leak source
- Requires a scanning system to provide across-track coverage
- Swath width of measurement is typically ≤30 m (100ft)
- Susceptible to surface induced noise
- Operates at low (unsafe) altitudes (typically 100ft)
- Very poor performance over water surfaces

NEW ERA AIRCRAFT

The current fleet of aircraft for New Era consists of Cessna 206, Cessna 182, Cessna 172 and Symphony 160. The company is looking to add two more Symphony 160 aircraft to the fleet later this year.

Cessna 206

Symphony 160

With the expected success of the new sensor in 2020 New Era will be adding aviation partners to accommodate the expected growth and demand for the leak indication that will come in the United States and Canada.

Helicopter option where it is most economical for the client.

NEW ERA TECHNOLOGY, INC.

CONTACTS

Home Office

New Era Technology, Inc.
755 Boardman-Canfield Road
Suite F6 West
Boardman, Ohio 44512

www.NewEraTechInc.com

AIRCRAFT LOCATIONS

North Lima, Ohio (4G4)

Salisbury, North Carolina (KRUQ)

Houston, Texas (KTME)

FUTURE NEWSLETTERS

Issue Dates:

September 2020
December 2020
March 2021

Future contents:

Progress reports on sensor development
Details on navigation system
Business Updates
Technical Updates