Helicopter-borne Leak Detection Instrument

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A new instrument called realSens™ has been designed by Synodon Inc. for the remote sensing detection of leaked natural gas. It employs a well-established remote sensing technology known as Gas-Filter Correlation Radiometry (GFCR), also known as Correlation Spectroscopy. Operationally, the instrument mounts on a helicopter flying at an altitude of 300 m (1000 feet). It is a passive push-broom imaging instrument, using reflected sunlight to make measurements of ethane with a spatial resolution of 2 m (6 feet) on the ground.

This article details the first field test of the realSens™ instrument, which occurred in Southern Arizona. The results of these tests showed that the instrument in its initial configuration is capable of detecting leaks of natural gas as low as 100 scfh.

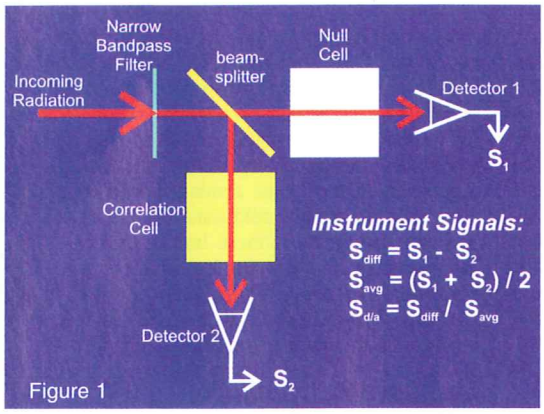

Figure 1

Gas-Filter Correlation Radiometry (GFCR)

Gas-Filter Correlation Radiometry (GFCR), also known as Correlation Spectroscopy, is a well-established remote sensing technology, first developed in the 1960s and first employed for atmospheric remote sensing of the atmosphere from space in 1970 (*Smith and Pidgeon, 1964, and Abel et al., 1970).*

Since its invention, a number of practical realizations of GFCRs have been developed, including the original Selective Chopper radiometers (SCR), pressure modulator radiometers (PMR), and length modulated radiometers (*Abel et al., 1970, Taylor et al., 1972, Drummond et al., 1978, Drummond, 1989, and Tolton and Drummond, 1997).*

For the realSens™ instrument, a new form of GFCR has been developed, known as a Simultaneous View Correlation Radiometer (SVCR) (*Miller et al., 2004).*

The main principle of a GFCR is to use a sample of the gas of interest as a spectral filter for the gas. As a consequence, it combines the advantages of the high-resolution spectral selectivity (to the gas of interest) of a spectrometer with the energy grasp of a low-resolution radiometer. The principles of the realSens™ GFCR are shown in ***Figure 1***. Incoming radiation is first passed through a narrow bandpass filter to select radiation from a spectral band of the gas of interest. The beam is then split by a beam splitter along two paths--one path containing a gas cell filled with the gas of interest (known as the correlation cell) and the other path containing no gas (known as the reference cell).

The radiant flux in each path is then measured by infrared detectors, and the signals are analyzed. The difference in the transmission along the two paths corresponds primarily to the absorption of the gas along the correlation cell path. Two signals from the detectors can be defined: an average signal (S_{avg}) corresponding to the average radiant fluxes on the two detectors, and a difference signal (S_{diff}) corresponding to the difference in the radiant fluxes. In operation, it is often convenient to define an instrument signal from a GFCR as the ratio of the S_{diff} to the S_{avg} ($S_{d/a}$), because it is unitless.

Simultaneous View Correlation Radiometer (SVCR)

The Simultaneous View Correlation Radiometer (SVCR) was designed specifically for the realSens™ instrument to detect the presence of leaked natural gas near the Earth's surface from an airborne platform. The realSens™ optics consist of a single optical chain split biaxially to form the two channels. Two 32-pixel linear detector arrays provide a 64x2 m (210x 6 feet) Field-of-View (FOV) swath, aligned perpendicular to the direction of motion. ***Figure 2*** shows the instrument in its pod mounted on a Bell 206L helicopter.

Figure 2

First Field Demonstration

The first field test customer demonstration of the instrument was performed on Jan. 13, 2009, at the Pima County Fairground (PCF) in Tucson AZ. The realSens™ helicopter took off from the Tucson International Airport (TUS) and flew southeast to the PCF. ***Figure 3*** shows a satellite image of the PCF including the position (+) of the simulated ethane leak in "parking lot 3." The leak was simulated using a gas bottle in a vehicle, with a hose to "leak" the gas away from the vehicle. The leak rates were varied between 0 and 200 scfh. The leaks were turned on approximately one minute before realSens™ passed overhead. On the day of the test, the winds were very high and gusty, blowing from the east-southeast at up to 30 mph. The helicopter made 10 passes over the PCF.

As an example of a leak detection, ***Figure 4*** shows the signals S_1 and S_2 for pixel pair 19 (pixels A19 and B19) of realSens during a pass over the PCF. The top figure shows the raw signals, and the bottom shows the change in $S_{d/a}$ during the pass. The leak is easily identified in the $S_{d/a}$ signal, and is highlighted on both graphs. Notice that the decrease in the raw detector signals due to variations in the surface reflectivity is significantly larger than the variation due to the absorption by the leaked gas. However, these surface reflectance variations are removed from the $S_{d/a}$ signal.

Table 1 lists the results of the first field demonstration of realSens™. Strong detections of the leak were observed in passes 1, 2,

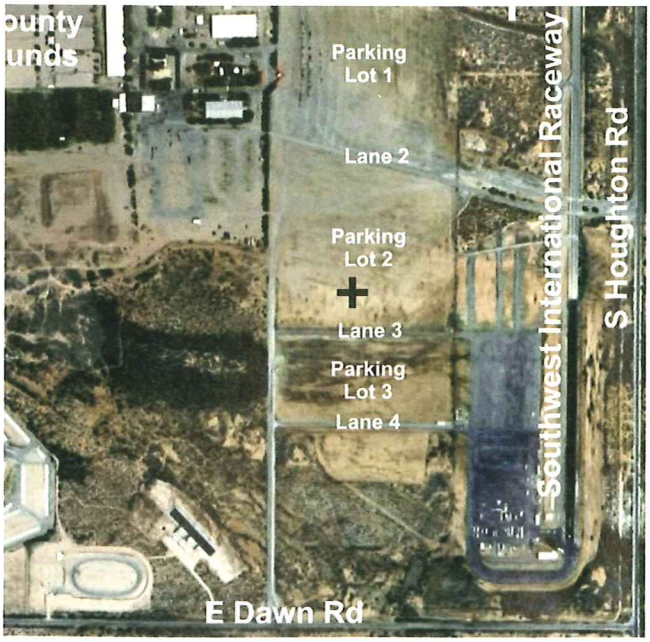

Figure 3

3 and 9 (with leak rates from 125 to 170 scfh). Weaker detections were observed in passes 5, 6 and 7 (with leak rates from 25 to 100 scfh). During pass 8, in which no leak was present (0 scfh), no leak was detected. Finally, in passes 4 and 10, the helicopter passed up-wind of the leak and consequently no leak was detected.

The realSens™ instrument pod also included a nadir-viewing visible camera. ***Figure 5*** shows the image of the PCF as the helicopter passed over the leak vehicle during pass 1. For these test flights, the pilot used the leak vehicle as the marker to pass over the leak. ***Figure 5*** also shows the direction the helicopter passed over the leak, the position of the leak (+), and contours of the detected leak concentrations. The wind was from the east-southeast, blowing the leaked gas just north of the vehicles. The leaked gas downwind of the leak can easily be seen.

Table 1: Jan 13, 2009 Flight Test Results

#	C_2H_6 Leak Rate (scfh)	Time	Altitude (ft)	Ground Speed (mph)	Result
1	125	11:23	4150	45	Strong detection
2	135	11:26	4100	70	Strong detection
3	170	11:31	4100	50	Strong detection
4	70	11:33	4150	65	missed Pass
5	65	11:36	4150	55	detected
6	100	11:38	4075	76	detected
7	25	11:41	4100	63	detected
8	0	11:43	4000	65	no
9	170	11:45	4100	60	Strong detection
10	120	11:47	4050	71	missed Pass

Summary And Conclusions

realSens™ is a new instrument for the remote sensing detection of leaked natural gas from a helicopter. It is an imaging Gas-Filter Correlation Radiometer (GFCR), providing 64 m (210 feet) wide swaths on the ground with a resolution of 2 m (6 feet). It is tuned to detect ethane or methane in the 3 μm region.

On Jan 13, 2009, the first field demonstration of realSens™ was performed in Tucson, Arizona. The tests were performed at the Pima County Fairgrounds, southeast of Tucson, and involved releasing ethane from a bottle. In total, 10 over-passes of the leak site were flown, of which only 9 passes with a leak. Of these 9 passes, the leak was detected in 7 passes. On the remaining 2 passes which did not detect the leak, the field-of-view (FOV) of the realSens™ instrument passed upwind of the leak. Also, on the pass in which the leak was not present, no leak was detected.

The leak rates for the field test was between 0 and 170 scfh of ethane, turned on approximately a minute before the over-pass of realSens™. The smallest leak detected was 25 scfh, and assuming a mixing ratio of 5% ethane in natural gas, it is estimated that the realSens™ instrument is capable of detecting a leak of natural gas as low as 500 scfh. Also, these flights were done in very high winds, much higher than under normal operation. 780-468-9568, adrian.bonica@synodon.com *P&GJ*

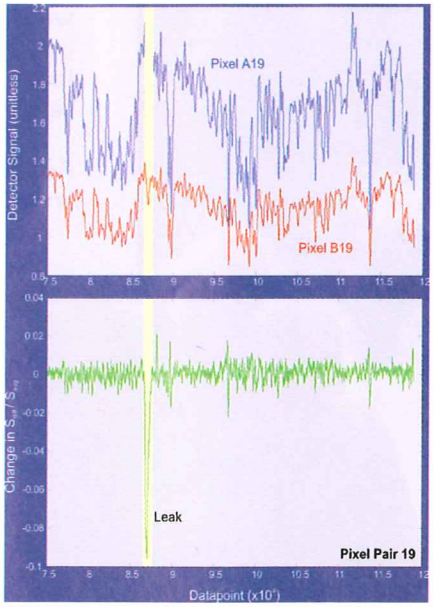

Figure 4

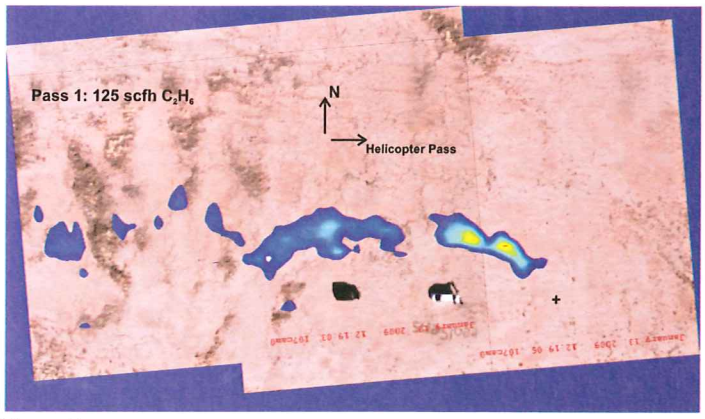

Figure 5

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Leak detection redefined through remote airborne ethane sensing

realSens improving accuracy while decreasing survey costs

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realSens has been optimized for detecting leaks and emissions from underground natural gas pipelines and related facilities.

Adapted from technologies developed for satellite based gas emissions monitoring, realSens is deployed on a helicopter flying at 1000 feet and accurately detects ethane leaks in a swath 200 feet wide. This significantly reduces the potential for false positives and the logistics problems these present in remote areas.

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