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ANGEL Assesses Pipeline Integrity

In September 2004, at ITT Industries, we tested our recently developed Airborne Natural Gas Emissions LIDAR (light detection and ranging) system, also known as the ANGEL system, at the Rocky Mountain Oilfield Testing Center (RMOTC). The test flights aimed to prove ANGEL'S ability to remotely detect gas leaks from transmission pipelines.

The integrated ANGEL system comprises data collection from airborne sensors as well as ground-based data processing and analysis. The system's airborne component includes a differential absorption LIDAR (DIAL) sensor, imaging device, computing hardware and software, and a navigation package that uses an integrated GPS/inertial measurement unit (IMU). The ground portion consists of a set of networked computer servers and workstations that provide the mission-planning data required to perform the airborne survey. This same system is then used to process, analyze, archive, display, and distribute the survey results to customers.

We employed the DIAL sensor because its tuned lasers can detect, quantify, and discriminate both methane and ethane. To position the leaks, DIAL measures the time-of-flight for the emitted laser pulse to strike a point on the surface of the Earth and return. The GPS/IMU subsystem provides the time and location at which the pulse returns. These two pieces of information can be used to determine the absolute position of the gas. The data collected by the system is used to create a visual model of the pipeline right of way and any leaks detected.

In addition to the emitter/detector, the sensor system incorporates active pointing and scanning subsystems. The pointing subsystem tracks the lasers to the pipeline right-of-way according to the preloaded mission-planning data. This enables the ANGEL system to precisely track the pipeline without human intervention, automatically compensating for aircraft motion (pitch, yaw, and roll) based on the integrated GPS/IMU. The scanning subsystem paints the right of way with a series of laser pulses, acquiring as many as 6,000 individual surface measurements per second.

While the DIAL sensor searches for leaks, the system simultaneously collects continuous, high-resolution imagery of pipeline routes. Georeferenced, color imagery gives context to the leak-detection data.

During the test, the ANGEL system detected, geolocated, and quantified leaks from a quarter-mile overhead while traveling at speeds of 150 miles per hour. In one week, it made 11 flights and 58 field passes, generating about 80 GB of data each day.

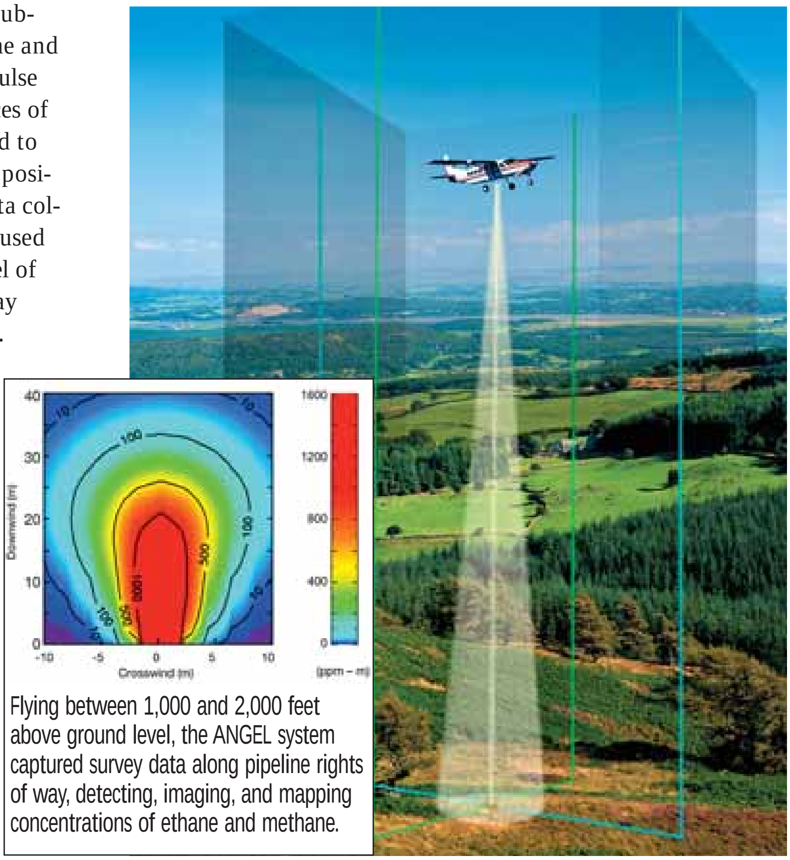
Based on the sensor's performance, the Department of Transportation Office of Pipeline Safety has now funded further development of the system, asking ITT to augment it to detect a wide variety of hazardous-liquid pipeline leaks.

Steven V. Stearns, Ph.D., senior scientist, ITT Industries Space Systems Division

PROJECT METADATA

Innovation: Using differential absorption LIDAR to detect and locate natural gas leaks

Participants: With support from the U.S. Department of Energy's National Energy Technical Laboratory and the Department of Transportation's Research and Special Programs Administration, ITT Industries Space Systems Division developed ANGEL using a DIAL unit from Coherent Technologies, Inc.; an Applanix POS/AV IMU; image-processing software from RSI – Research Systems, Inc.; and ArcGIS from ESRI.



Flying between 1,000 and 2,000 feet above ground level, the ANGEL system captured survey data along pipeline rights of way, detecting, imaging, and mapping concentrations of ethane and methane.