Airborne Pipeline Inspection System (ALPIS)
Field Demonstration at the
Rocky Mountain Oilfield Testing Center (RMOTC)

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Summary Report

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The Airborne Lidar Pipeline Inspection System (ALPIS) program started in 2001 when the U.S. Department of Transportation (DOT) provided funding to LaSen, Inc. to develop technology for the airborne inspection of natural gas pipelines. The need for a rapid, accurate and economical means of pipeline inspection was highlighted by a series of recent pipeline accidents, including pipeline explosions near Jefferson Township, NJ and Carlsbad, NM which claimed several human lives. In December 2002, the U.S. Congress passed the Pipeline Safety Improvement Act which set forth more stringent criteria on pipeline safety and integrity management. To address the pressing need for new and improved methods of pipeline inspection, LaSen was contracted by DOT to adapt the company's laser sensor technology, originally developed under an SBIR program with the U.S. Air Force, to the specific problem of airborne pipeline leak detection. The past years have seen ALPIS develop from a laboratory prototype to a field-deployed and viable tool for pipeline inspection.

LaSen's Airborne Lidar Pipeline Inspection System is based on a Differential Absorption Lidar (DIAL) chemical sensor operating in the mid-IR (3—5-μm) range. The laser beam is transmitted down from the aircraft to illuminate the area on the ground above the buried pipe (Figure 1). After reflection from the ground, the beam is collected by the sensor's receiver and the amount of received energy is measured. If the laser beam passes through a methane plume emanating from a pipeline leak, the received energy will be diminished due to the absorption of laser light in the plume. This absorption signature is used to located the leak and assess its magnitude.

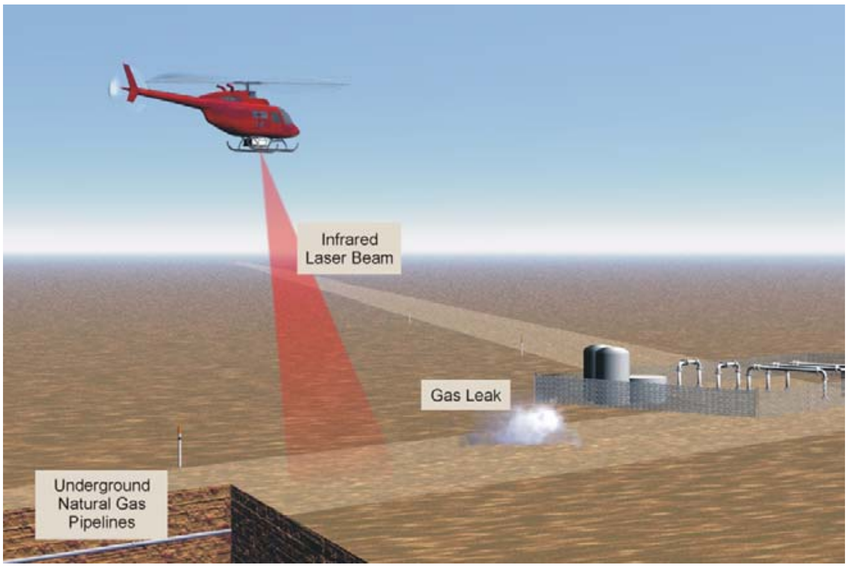

Figure 1. ALPIS operational principle.

During Phases I and II of the program, LaSen successfully addressed a number of technical challenges involved in deploying the laser sensor on an airborne platform and maximizing its efficiency for natural gas detection. In Phase I, the primary emphasis was on ruggedizing the system to make it amenable for deployment on airborne platforms, particularly helicopters. During Phase II, the laser chemical sensor was integrated with a suite of auxiliary sensors, such as a Global Positioning System (GPS) receiver, rangefinder and a digital imaging camera. As a result, ALPIS can not only detect leaks, but also map their location on a GPS map and provide a visual image of the problem area. Additionally, LaSen developed software that combined the functions of system control, data acquisition, processing and archiving in a user friendly interface. Phase II culminated in a series of successful tests on the pipeline system of El Paso Natural Gas Company.

The objective of Phase III of the program completed in 2004 was to implement a series of design upgrades in order to further enhance the system's performance and effectiveness. First, the scanned area on the ground was extended in order to provide a better coverage of the pipeline's right of way. Second, data acquisition and processing were made concurrent, eliminating gaps in the ground coverage that affected the previous ALPIS designs. Third, a calibration cell was integrated into the system making it immune to ambient temperature variation. As a result of the Phase III effort a second generation pipeline inspection system (ALPIS-II) was created (Figure 2). Unlike its predecessor, ALPIS-II is mounted externally to the helicopter via a standard mounting bracket which makes it easily transportable between same model helicopters.

Figure 2. ALPIS-II mounted to a Bell Jet Ranger helicopter.

The capabilities of ALPIS-II were demonstrated in a U.S. Department of Energy (DOE) sponsored tests of remote leak detection technologies that took place at the Rocky Mountain Oilfield Testing Center (RMOTC) near Casper, WY during the week of Sept. 13—17, 2004. In these tests, the LaSen system, along with equipment from several other companies, performed inspection of a 7.5-mile long stretch of a simulated pipeline. Leaks of varying magnitude were distributed along the route in locations unknown to the equipment provides, with the exception of a calibration leak whose location and leak rate for each date were disclosed. Each company was allocated two time slots each day and given an opportunity to either drive of fly the survey route.

Figure 3. Map of the test site (NPR-3) showing the simulated pipeline route and detected leak sites.

Overall, nine out of ten ALPIS missions were competed successfully. (The first flight had to be aborted due to a power supply failure.) It should be noted that the conditions for airborne system testing at RMOTC were less than ideal. First, 20-mph plus winds typical for Wyoming made accurate tracking of the pipeline difficult if not impossible at times. Second, parts of the survey route crossed over rough terrain which increased the level of noise due to ground clutter. Nonetheless, the tests provided an excellent opportunity to evaluate the system over a wide range of conditions and leak rates. A total number of 45 leaks were detected at 7 different sites along the survey route in the course of 5 days of testing (Figure 3). The number of false positives for the same period was 11. In addition, calibration leaks ranging from 15 scfh to 5000 scfh were successfully detected.

The RMOTC demonstration also presented LaSen with a unique venue to gauge our technology against the technologies of our peers. It is safe to say that airborne laser technology, such as is implemented in the ALPIS system, is the most advanced and effective technology for inspection of transmission natural gas pipelines.

The level of performance demonstrated in the RMOTC test is not representative of the system's ultimate capability. LaSen is continuously improving the leak detection technology. By the end of 2004, LaSen will field the next generation of ALPIS system with an upgraded laser transmitter allowing for higher survey speed and increased accuracy of leak detection. The current phase of the ALPIS program will extend the system's capability to the detection of leaks from various hazardous liquid pipelines. These and other anticipated improvements will further enhance the system's effectiveness in ensuring the safety and reliability of the U.S. pipeline system.

Appendix A. Answers to specific DOT questions

1. *What was your overall opinion of this demonstration event? (positive & negative opinions)*

   Well organized event, especially considering the challenge of balancing the needs of different equipment providers.

2. *Did you have any difficulties setting up your equipment?*

   No

3. *How efficiently did your calibration and data collection runs work out?*

   9 out of 10 data collection missions were completed successfully. The system sensitivity demonstrated in these tests was consistent with the previous estimates.

4. *Did you feel this demonstration was a fair test of your technology?*

   Yes

5. *Would you welcome further opportunities to demonstrate your technology?*

   Yes

6. *If the demonstration test were repeated in 12-18 months what changes would you suggest?*

   We believe that a simulated pipeline needs to have visual indicators to facilitate its tracking from an aircraft.