Extended Performance Handheld Sensor for Remote Detection of Natural Gas Leaks

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National Energy Technology Laboratory
Morgantown, West Virginia

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HEATH CONSULTANTS

Extended Performance Handheld Sensors for Remote Detection of Natural Gas Leaks - Objective

VG02-315-1

- **Physical Sciences Inc. and Heath Consultants have previously developed a walking survey tool for natural gas distribution networks (RMLD)**
- **Performance optimized for quasi-stationary surveys of residences**
- **Objective of Cooperative Phased Research Agreement is to extend function and capabilities based on:**
  - community needs
  - market assessment
- **Consider mobile application, greater range or sensitivity, improved detection thresholds, atmospheric compensation**
- **Recommend extended performance RMLD concept to NETL**
- **Fabricate and demonstrate enhanced performance sensor in laboratory**

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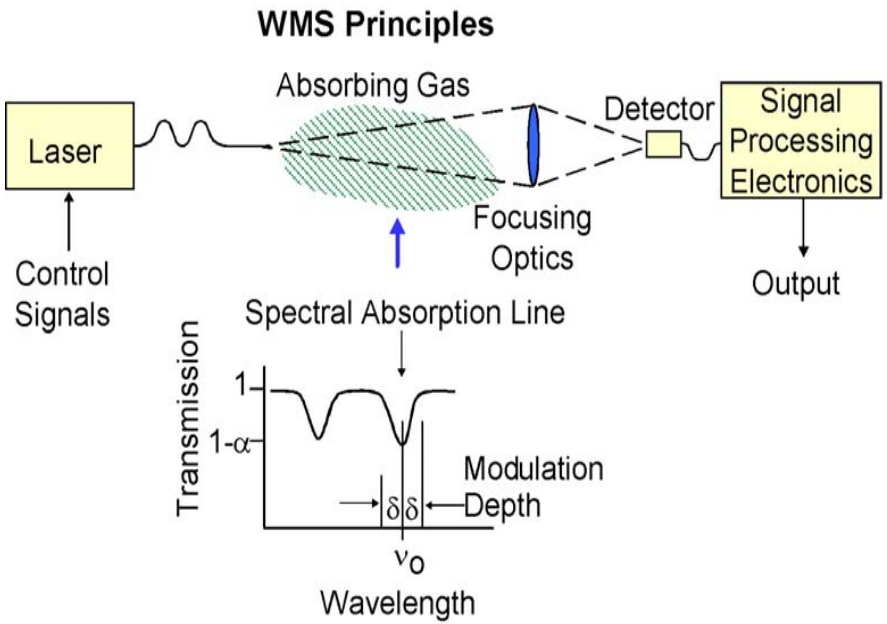
Existing RMLD Survey Tool - Objective

To develop a device that can detect methane from outside the leak plume using laser light technology

- **It must be portable, fieldworthy, and lightweight**
- **It must be as sensitive as existing leak surveying tools and methods**
- **It must be able to locate the presence of methane gas only – gas leak yes or no!**
- **It is not intended to be a leak pinpointing/ measurement tool (CGI)**

Principles of Operation



- The RMLD is based on the established Tuneable Diode Laser Absorption Spectroscopy (TDLAS)
- Laser beam projected from devices, through gas cloud, to topographic surface up to 100 ft (30 m) distant
- Laser light scattered from topographic surface is partially collected by device
- Wavelength Modulation Spectroscopy (WMS) is utilized to deduce the path-integrated gas concentration

Benefits

- **A portable RMLD unit will improve walking survey operations:**
  - hard to reach or difficult areas (e.g., over or through fences, under parked vehicles)
  - service leak survey can be performed near or at sidewalk
- **Check inside buildings or confined spaces from outside via a closed window or access**
- **Estimates show productivity savings from 20% to 40% for the average size utility**
  - for some companies this can result in annual savings of $500,000

RMLD Performance Criteria

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- **Able to locate leaks from 100 feet away**
- **Achieve sensitivity to few ppm-m methane**
- **Response time needs to be a fraction of a second**
- **Laser light source needs to be eye-safe**
- **Battery recharge to be >8 hours**
- **Must be lightweight, rugged and weather-proof**
- **User friendly interface with familiar signals**
- **Withstand temperatures from -20°F to 120°F**
- **Sales price around $10,000**

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RMLD Basic Overview

- **Laser light is projected over a distance onto a reflective target (e.g., grass, wall, etc.)**
- **A fraction of the light is diffusely scattered from the target surface and returns back to the receiver**
- **If methane is present a portion of the returning light will be modulated at twice the frequency**
- **Returning light is efficiently collected and focused onto a detector**
- **Synchronous detection and amplification to produce methane readings in ppm-m**
- **Calibration verified by gas in absorption cell**

RMLD - Laser Light Path

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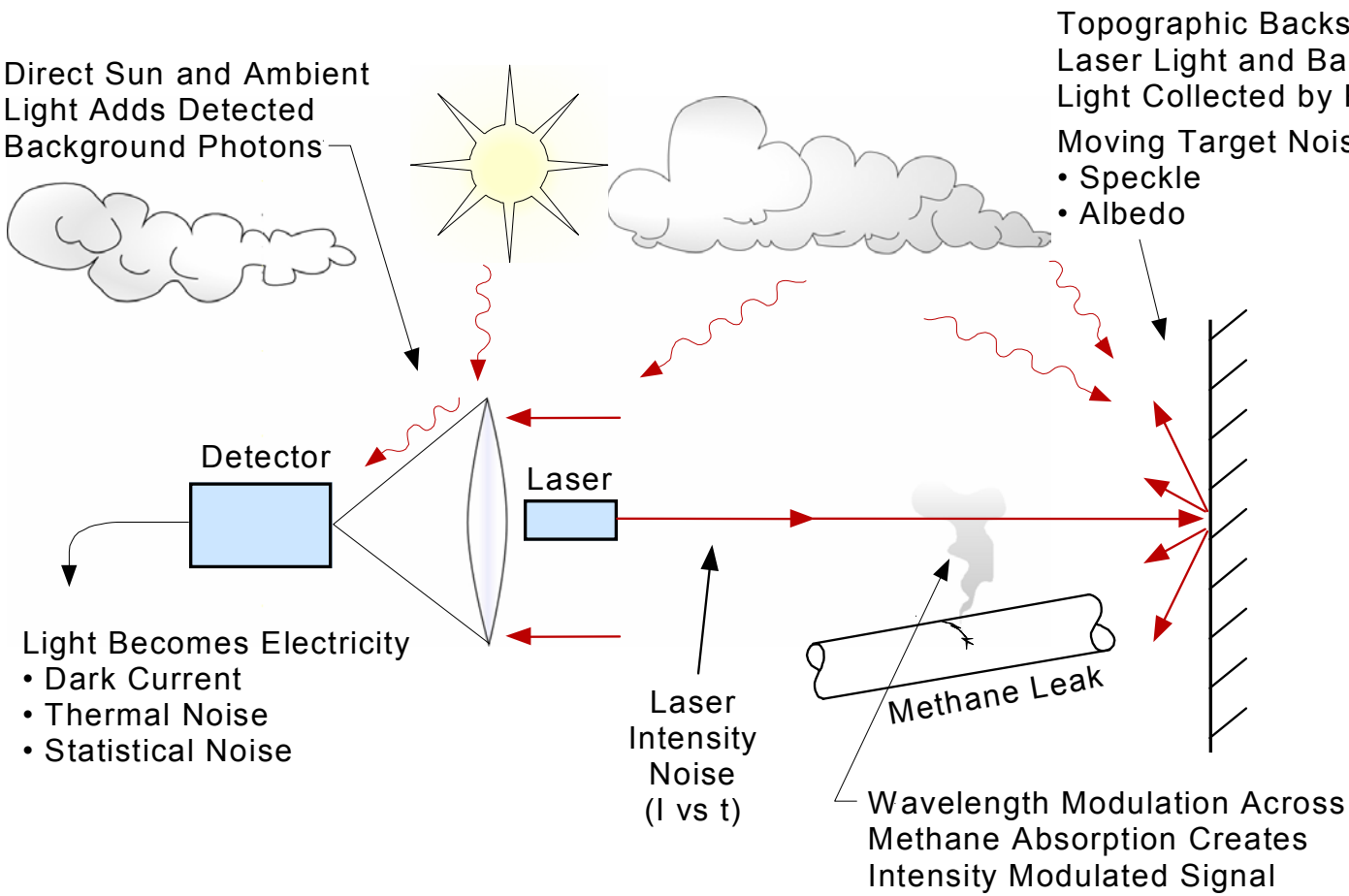

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RMLD Development
An Aggressive Schedule

- **The RMLD project was initiated in January 01**
  - project phases
    - 1-Assessment – review competing technologies
    - 2-Feasibility – product spec and sensor design
    - 3-Prototype development and test (EP)
    - 4-Develop advanced prototype (AP)
    - 5-Develop Pre-Production units

- **An AP unit will be delivered to NYGAS in December 2002 for field tests**

- **From concept to "Alpha" prototype in less than 2 years!**

Development of Portable Electronics

- **Previous TDLAS systems required rack of electronics for:**
  - laser control
  - laser modulation
  - signal detection/amplification
  - signal demodulation
  - power conditioning
- **Decided portability key to concept demo (risk)**
- **Careful power management throughout design**
- **Single board (6”square) electronics in control unit**
- **Four ounce battery provides >8 hours of operation**

RMLD - EP Components

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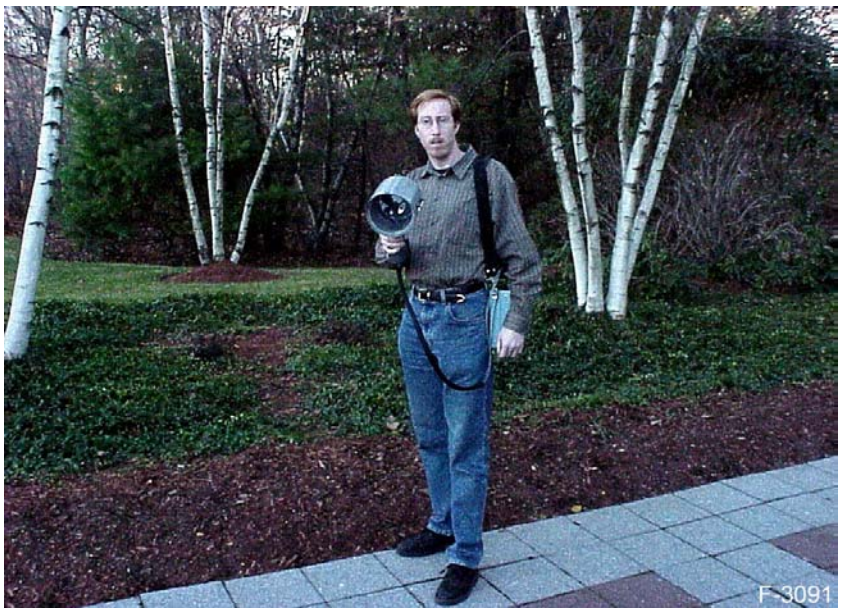
- **Control pack (hip mount with harness)**
  - laser emitter subsystem
  - battery pack for 8 hours use
- **Transceiver - laser transmitter/receiver/optics**
- **Umbilical cord - fiber optic/electrical connection**



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RMLD - Leak Scan Operation

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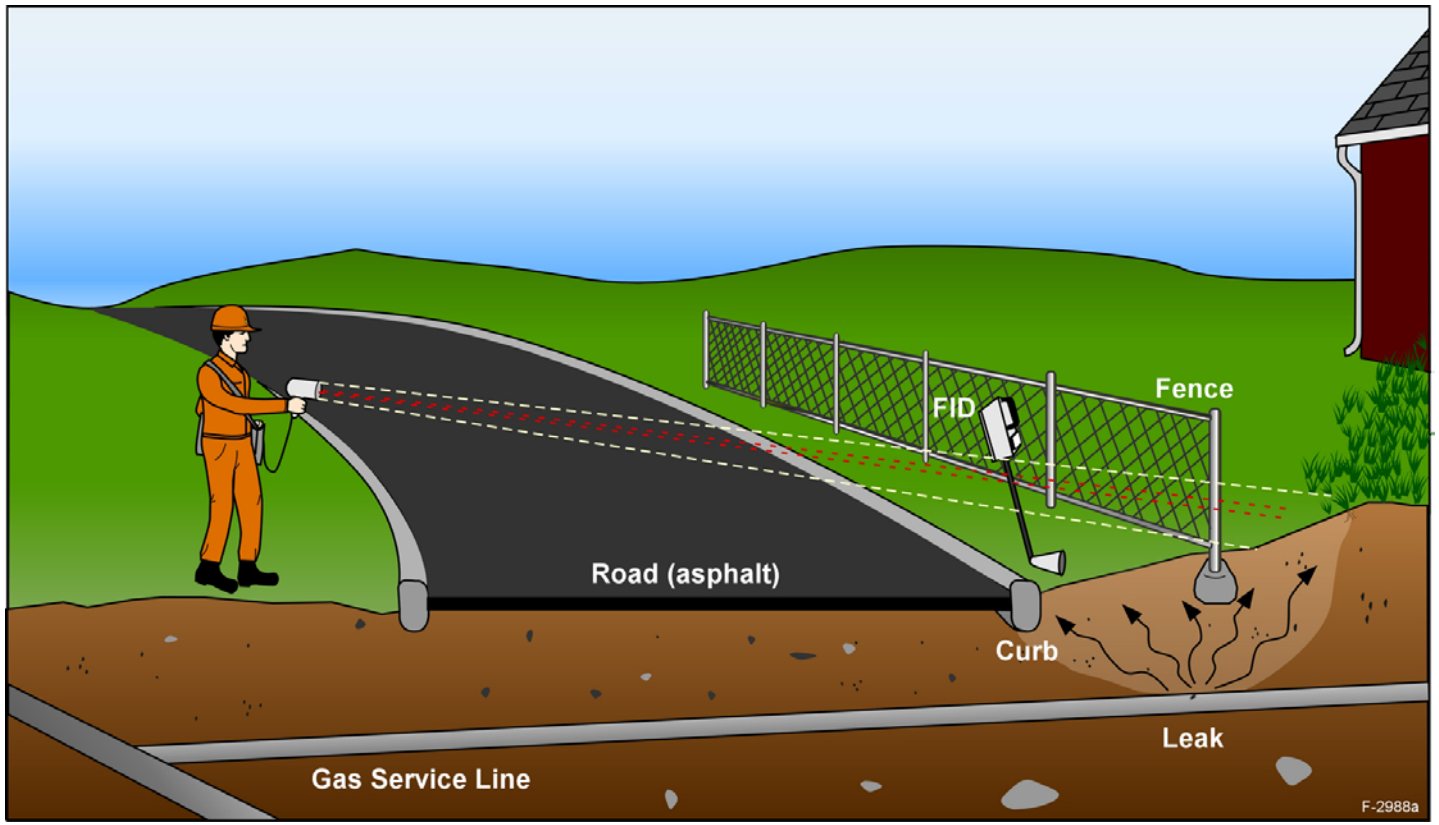
User interface:

- Audible alarm
- Bar graph
- Touch pad menu
- Target sights



Several leak scan methods being evaluated!

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Methane Column Concentration

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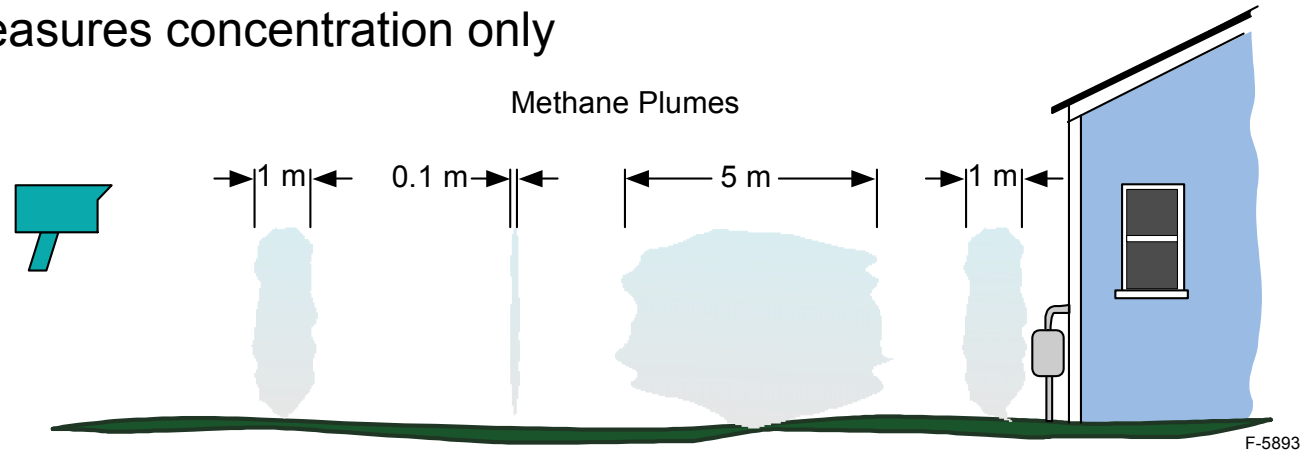
- **RMLD measures concentration x plume width x 2**
  - FI measures concentration only



FI (ppm)				
10	0	0	0	RMLD = 20
0	0	0	10	(ppm-m) 20
0	10	0	0	2
0	0	2	0	20
2	0	2	2	28

- **RMLD operates differently than FI**
- **Detects everywhere along sight line (do not need to be in plume)**
- **Sum of concentration x width**
- **Path summation permits rapid survey**
- **Triangulation to begin localization**

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RMLD Field Test Results

- **Successful EP testing with "real" leaks in Lowell, MA - Nov. 2001**
  - found 14 out of 16 leaks
  - known and blind leaks with FI follow-up
- **Successful EP+ testing in outside facility for gas leak training – April 2002**
  - able to setup controlled leaks
  - direct comparison to FI
  - found 20 out of 22 leaks
  - able to find leak that FI missed (meter)
- **Needed to improve sensitivity and light filtering problems**

RMLD Data Collection at 30 ft Upwind

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Gas Detection with Varying Backgrounds

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Survey Detection of Leak Behind Oleander Shrub

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Gas Detection Through Closed Window

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Leak Under (Bob's) Parked Vehicle

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Thermal Testing Summary

- **RMLD CU subjected to varying environmental temperatures. Ambient, heat sink, laser, and PCB temperatures monitored.**
- **RMLD operates from 0 to 122°F (-18 to 50°C). Meets specification.**
- **Laser attains operating "setpoint" temperature on startup at all temperatures within ~5 seconds ("left out in the cold" or "in the sun")**
- **Extreme temperatures yield laser temperature drift of 0.2°F. If RMLD is calibrated at room temperature, CH_4 sensitivity is 64% at 0°F, 87% at 32°F, 100% at 72°F, 89% at 95°F, 71% at 122°F.**

Battery Lifetime

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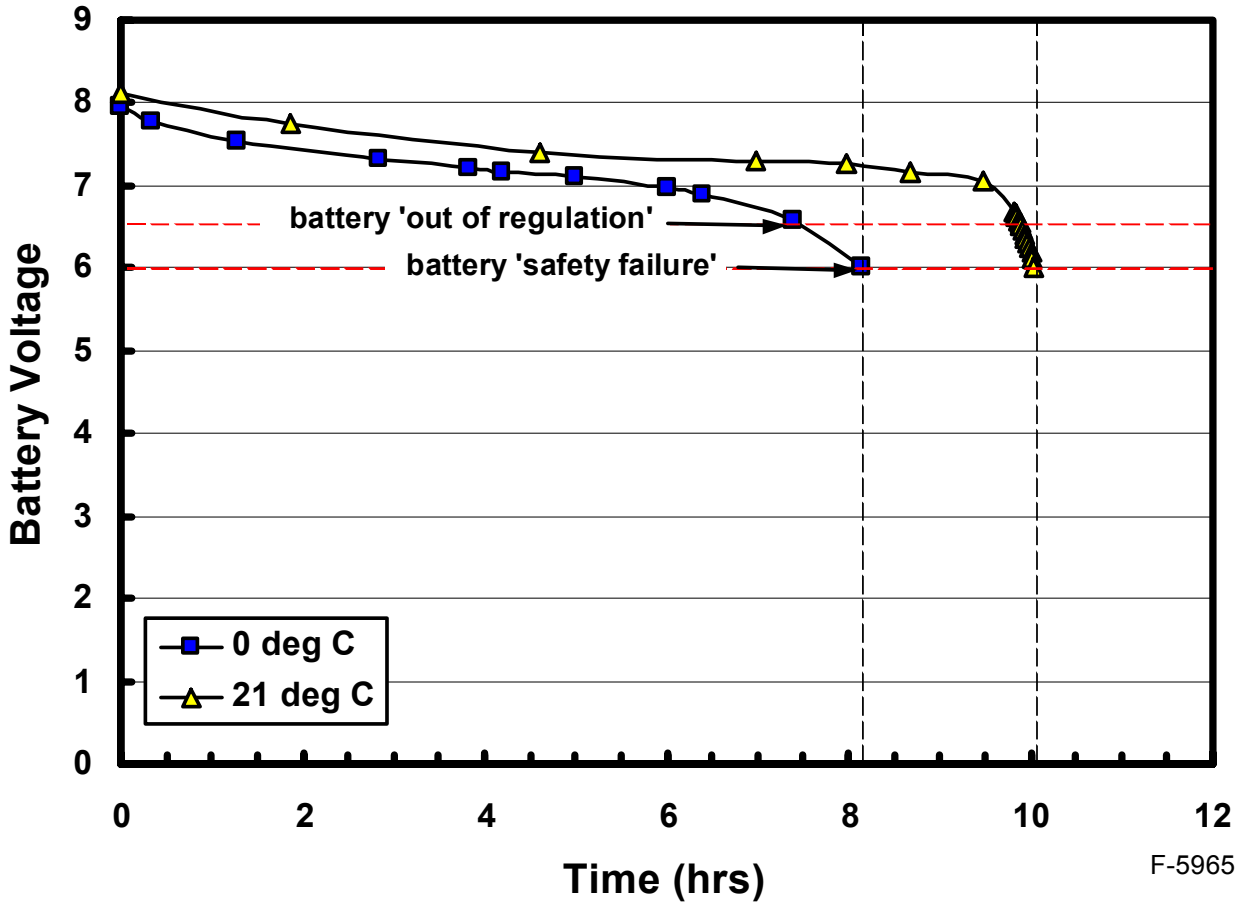

- **1.8A-hr (7.4V) Li ion Battery meets 8 hour lifetime at 32°F specification**

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AP Transceiver Housing Showing Reduction in Size from EP

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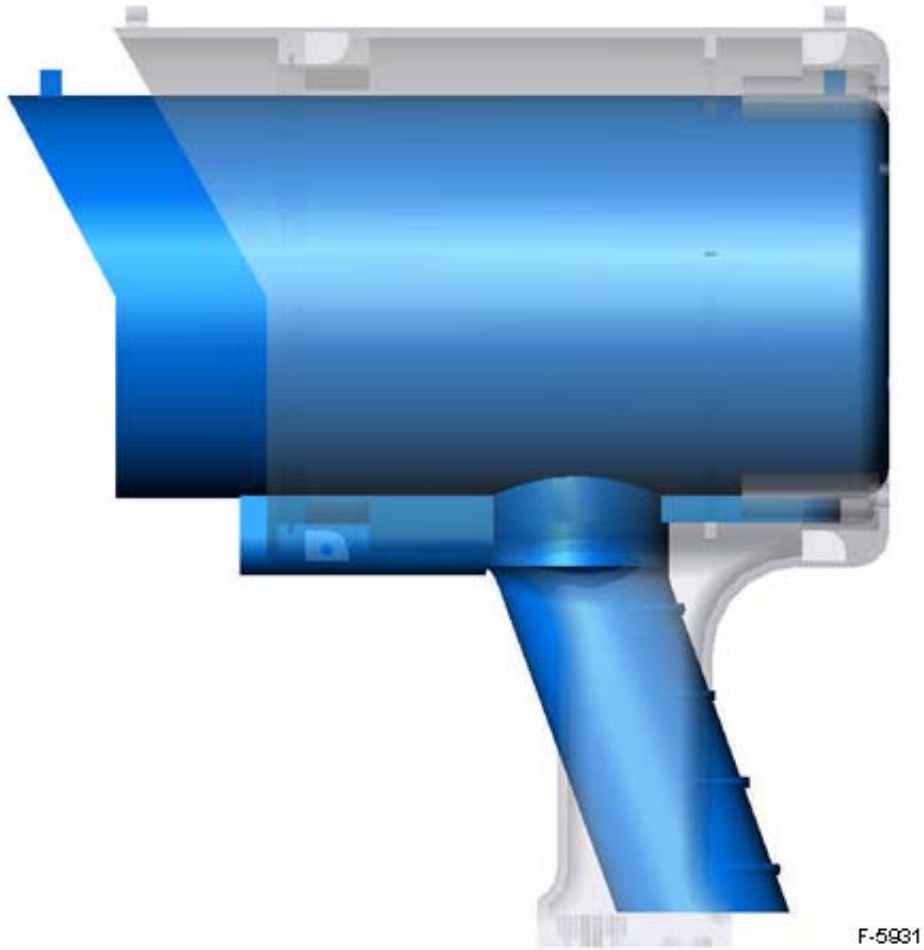

Key Accomplishments

- **RMLD has gone from a concept drawing to a fieldworthy prototype in a very short time!**
  - went from lab-rack to a “true” portable unit
  - able to achieve laser control and stability
  - reduce noise effects – electronic and environmental
  - optimize optics design (cost and performance)
  - optimize physical design
  - demonstrate on a variety of backgrounds
  - flawless operation in extreme weather – cold and hot
  - develop user-friendly interface – minimal training
- **Sensitivity and light filtering problem solved**
- **Major technical problems have been resolved**

Alpha Prototype

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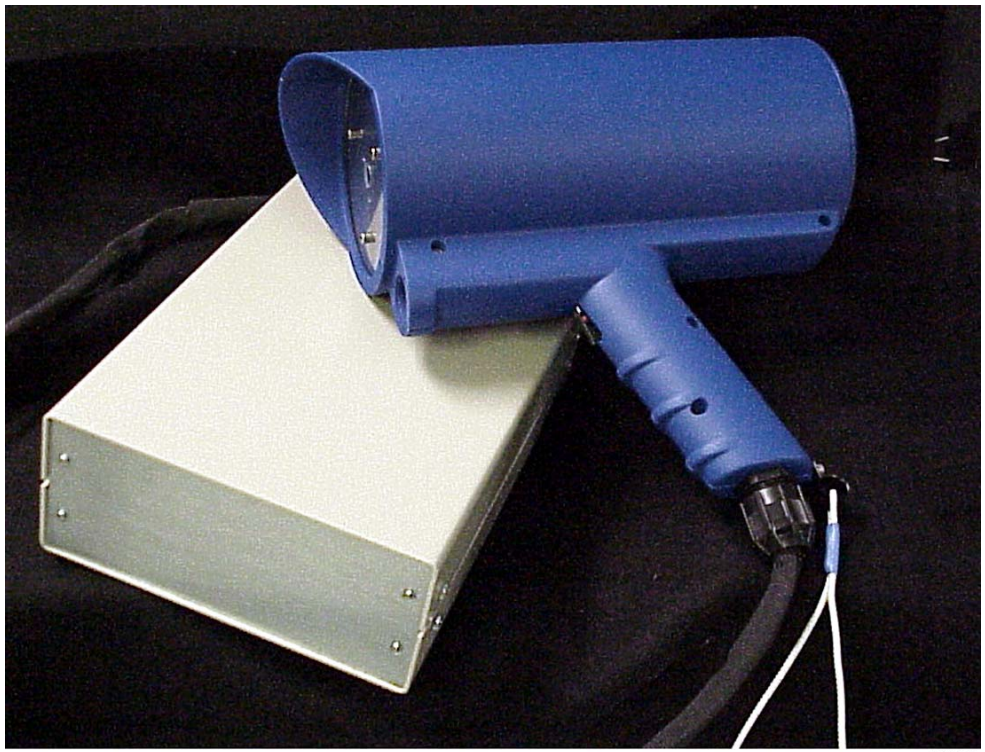

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- **Improved user interface**
- **Improved sensitivity and light rejection**
- **Commercial Partner integral to program**
- **Delivery to sponsor consortium in December**
- **Product introduction Fall 2003**

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RMLD Development Schedule

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- **Critical Design Review – Completed Aug 2002**
- **Delivery of AP units to NYGAS- Dec 2002**
- **Field tests at company locations**
- **Provide feedback for pre-production RMLD**
- **Heath to build pre-production models**
- **Introduce RMLD at AGA 2003 Ops Conference**
- **Pre-production models to be fully tested – Summer 2003**
- **Seeking community support for new stand-off detection technology**

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RMLD-XP Cooperative Research Agreement Tasks

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1.0 Research Management Plan (Month 1)
2.0 Technology Status Assessment (Month 2)
3.0 Design of extended performance RMLD (Month 2)
- 3.1 Spatial range extension
- 3.2 Performance improvements
- 3.3 Power enhancement
- 3.4 Operation wavelength
- 3.5 Survey user community
- 3.6 Conceptual design of extended performance RMLD (-XP)
- 3.7 Present recommendation to NETL staff

4.0 Fabricate and demonstrate RMLD XP prototype in laboratory
5.0 Ethane detection feasibility
6.0 Annual Review Meeting participation; Final briefing and report