Optical Technology for Tracking Turbulence, Visibility & Hazardous Wind

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Presentation Overview

- Who is OSi - Optical Scientific, Inc.?
- Scintillation sensors - capabilities and potential applications
- Explain basic concept of scintillation
- Overview of optical wind / flow / turbulence sensors
- Real world examples of how this technology is used
- Characteristics and advantages of scintillation technology
- Wrap up / time for Q&A

OSi Introduction

- Located in Gaithersburg, Maryland -- founded 1985
- Design, develop, and manufacture advanced opto-electronic systems for remote sensing applications
- Market to customers around the world in areas of process control, meteorology, research organizations, road weather, aviation safety, and environmental monitoring
- Inventor and manufacturer of:
  - LEDWI - present weather detector fielded at 1100 airports in USA
  - DSP-WIVIS - present weather/visibility sensor, 3000 road weather sites
  - OFS - optical flow sensor used in 1000 petrochem & other facilities
  - LOA & OWV - long path sensors to measure wind, turbulence, visibility

Scintillation Based Sensors

- LOA - Long-baseline Optical Anemometer
- OWV - Optical Wind / Visibility sensor
- OFS - Optical Flow sensor
- Other sensors and systems based on same scintillation technology:
  - LEDWI - Light Emitting Diode Weather Identifier
  - OWI - Optical Weather Identifier
  - DSP-WIVIS - DSP-based Weather Identifier / VISibility sensor
  - MAWOS - Modular Automated Weather Observing System
  - HazMET - Hazardous Meteorological system (portable)

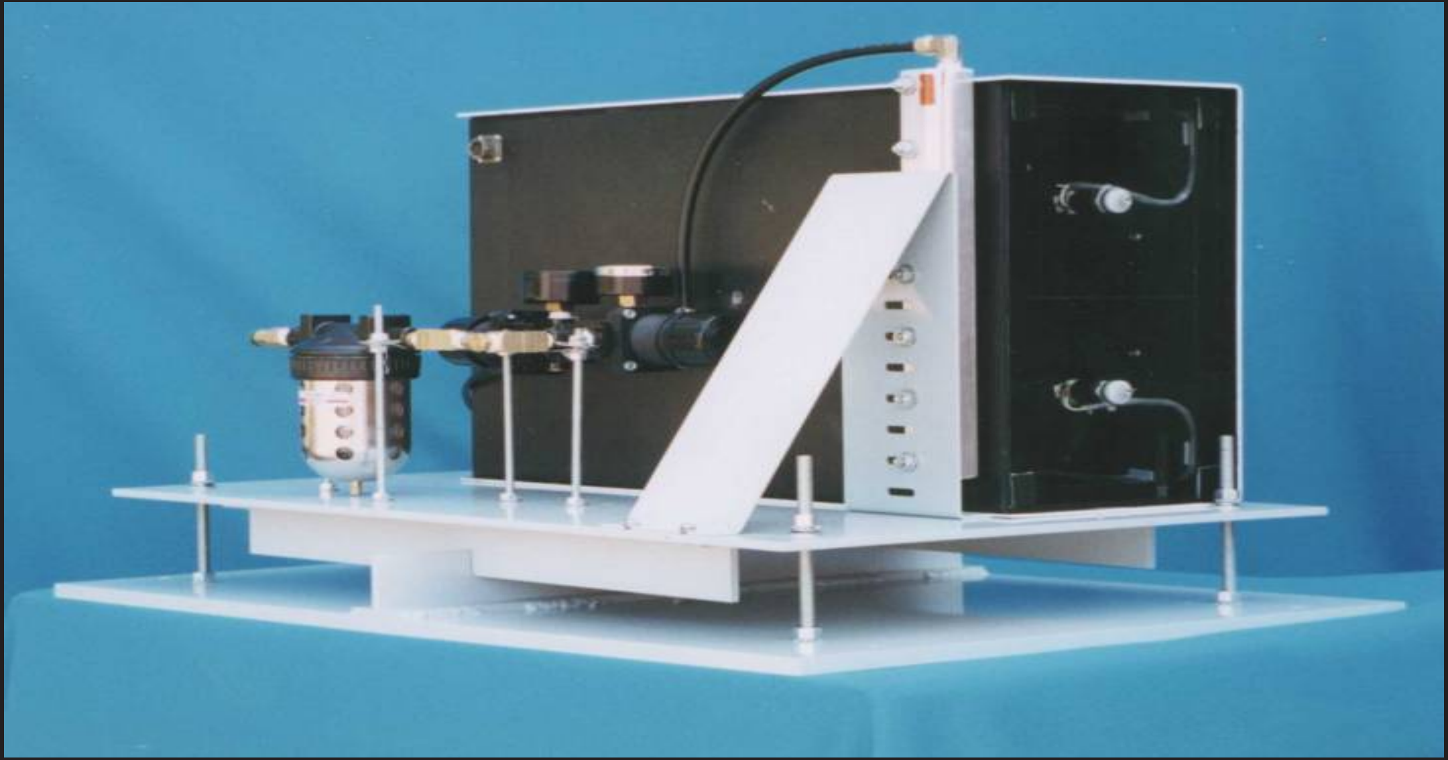
OSi Introduction

Optical Flow Sensor & Optical Wind/Visibility

- OFS-2000 -- 0.1-15m

- OWV -- 10-200m

LOA Receiver for Aluminum Smelting



Scintillation-based Sensor Applications

- Current applications of scintillation technology include…
  - Measuring precipitation intensity (ORG, OWI, WIVIS)
  - Discriminating between rain / snow / hail (OWI / WIVIS)
  - Combustion process air flow measurement (OFS)
  - Stack emissions monitoring (OFS)
  - Flare line flow monitoring (OFS)
  - Aluminum potroom flow monitoring (LOA)
  - Crosswind correction for ballistics testing (LOA)

LOA / OWV Applications

- Wake vortex & microburst measurement at airports
- Low level plume dispersion & modeling verification
- Facility fence-line wind monitoring
- Micrometeorology: Convergence / divergence - diffusion studies
- Measure pollution induced visibility
- 1D or 2D wind profiles / cross winds
- 3D wind - measure up drafts / down drafts
- Turbulence strength (Cn2)

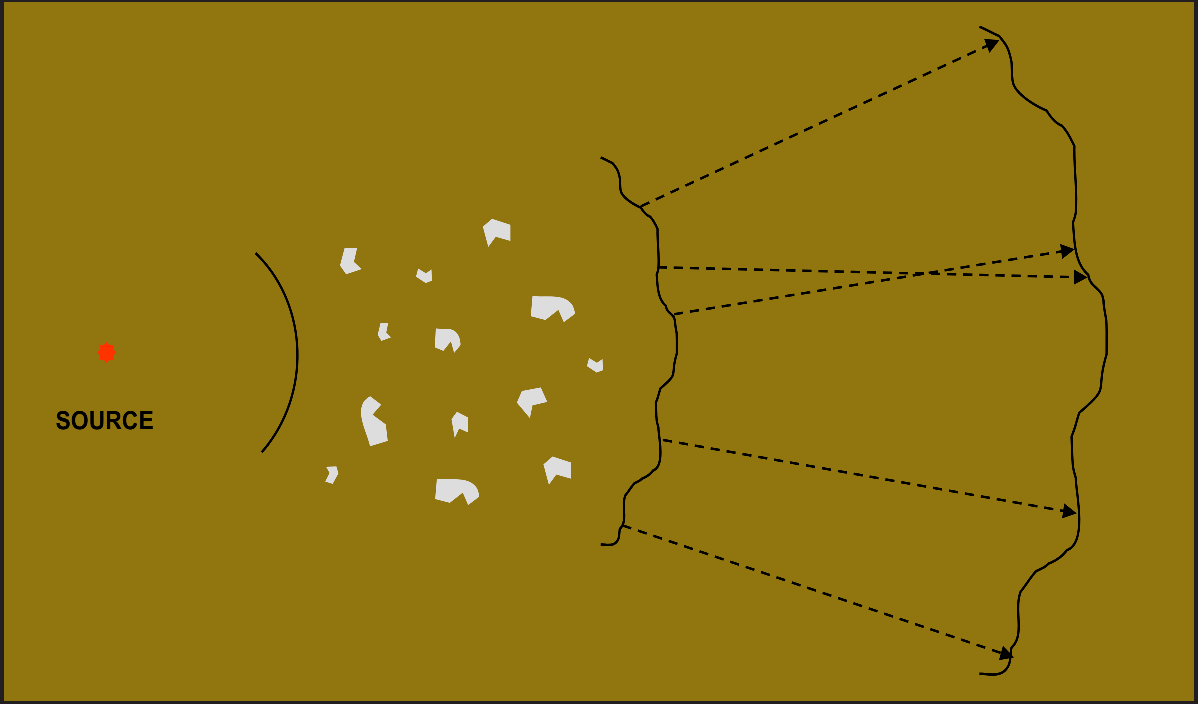
How Can Optics Measure Flow?

- OSI's optical wind and flow sensors use scintillation as a detection method.
- Developed by Dr. Wang and NOAA in the 1970's to measure cross-wind and turbulence over paths up to 10 Km or longer.
- The LOA and OWV sensors operate on a combination of optical extinction and optical scintillation
- So what exactly is 'scintillation'?

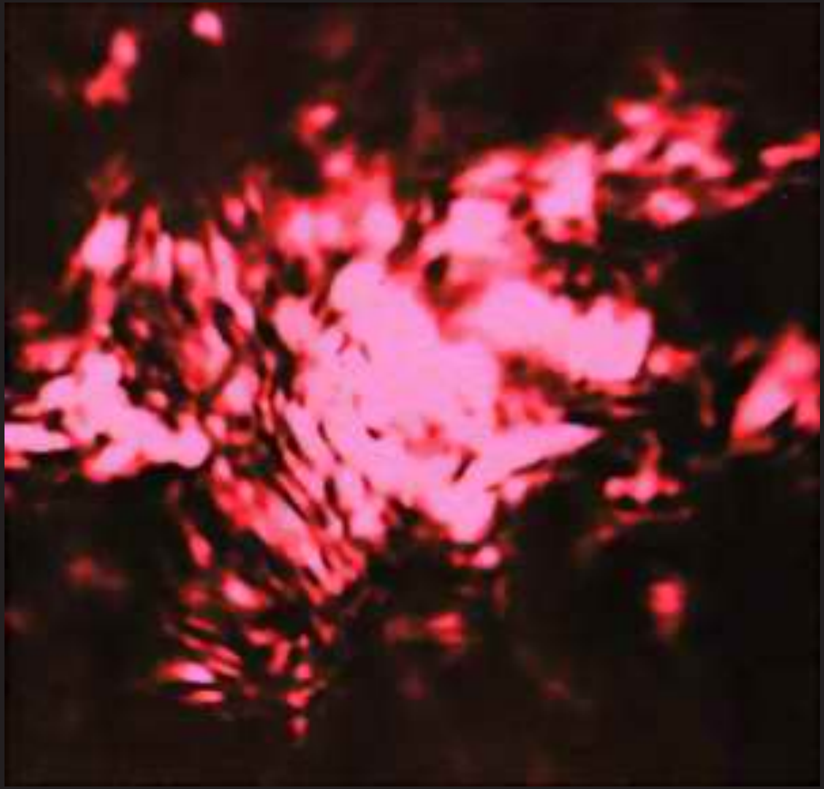
What is Scintillation?

- Scintillation is the mechanism used to optically measure flow.
- Scintillation: changes in the apparent position or brightness of an object observed through media such as air or water.
- Caused by refraction in naturally occurring parcels of air with different density / temperature from surroundings.
- Examples of scintillation include:
  - Twinkling of stars
  - Heat shimmer over hot pavement
  - Patterns on bottom of swimming pool

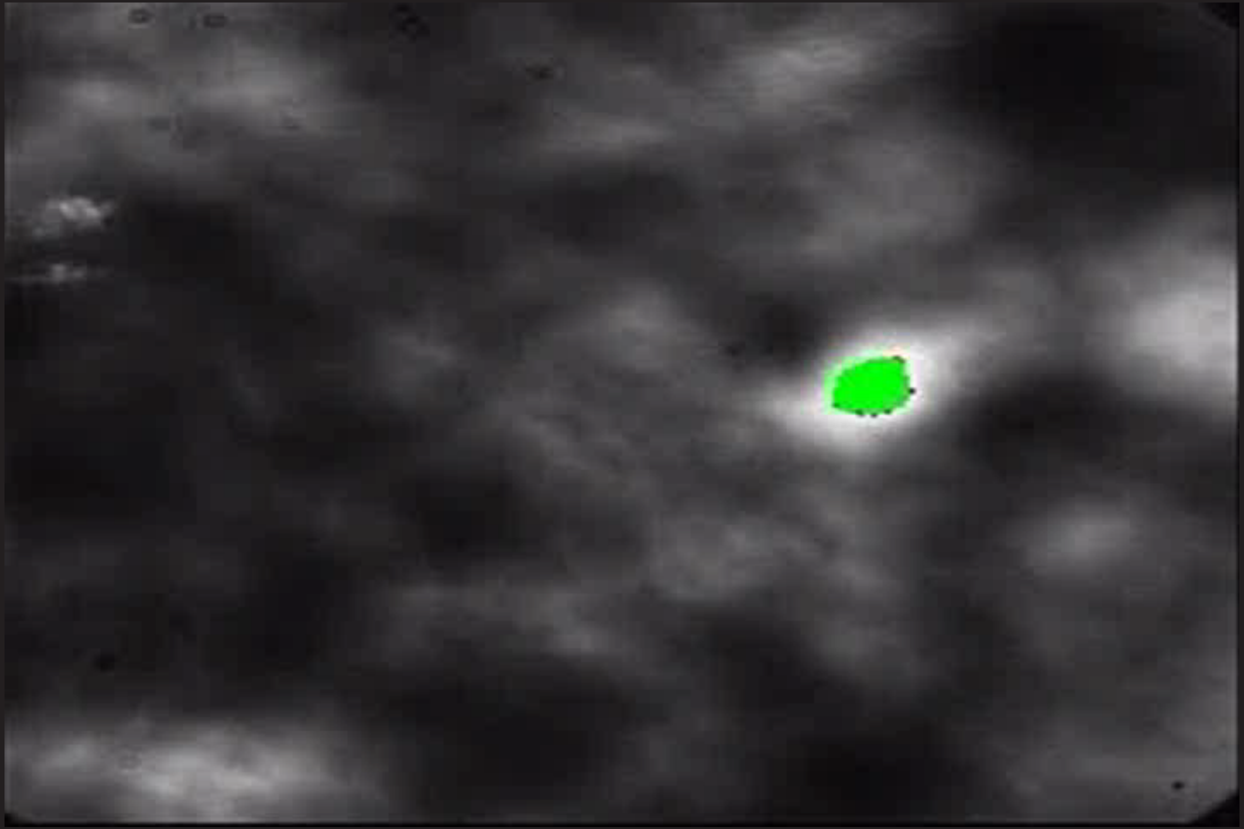
What is Scintillation?



Atmospheric-Induced Optical Scintillation



Can You See the Wind?

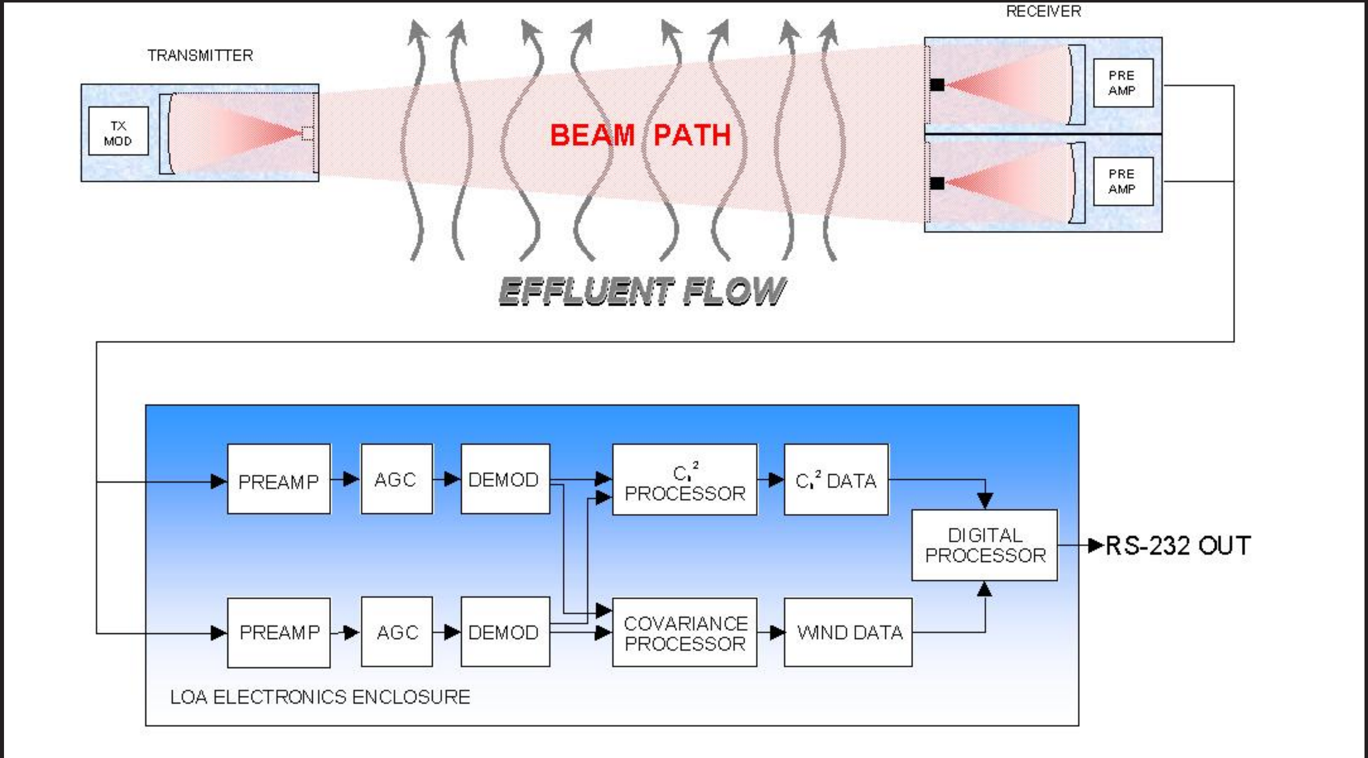


History of Scintillation-based Sensors

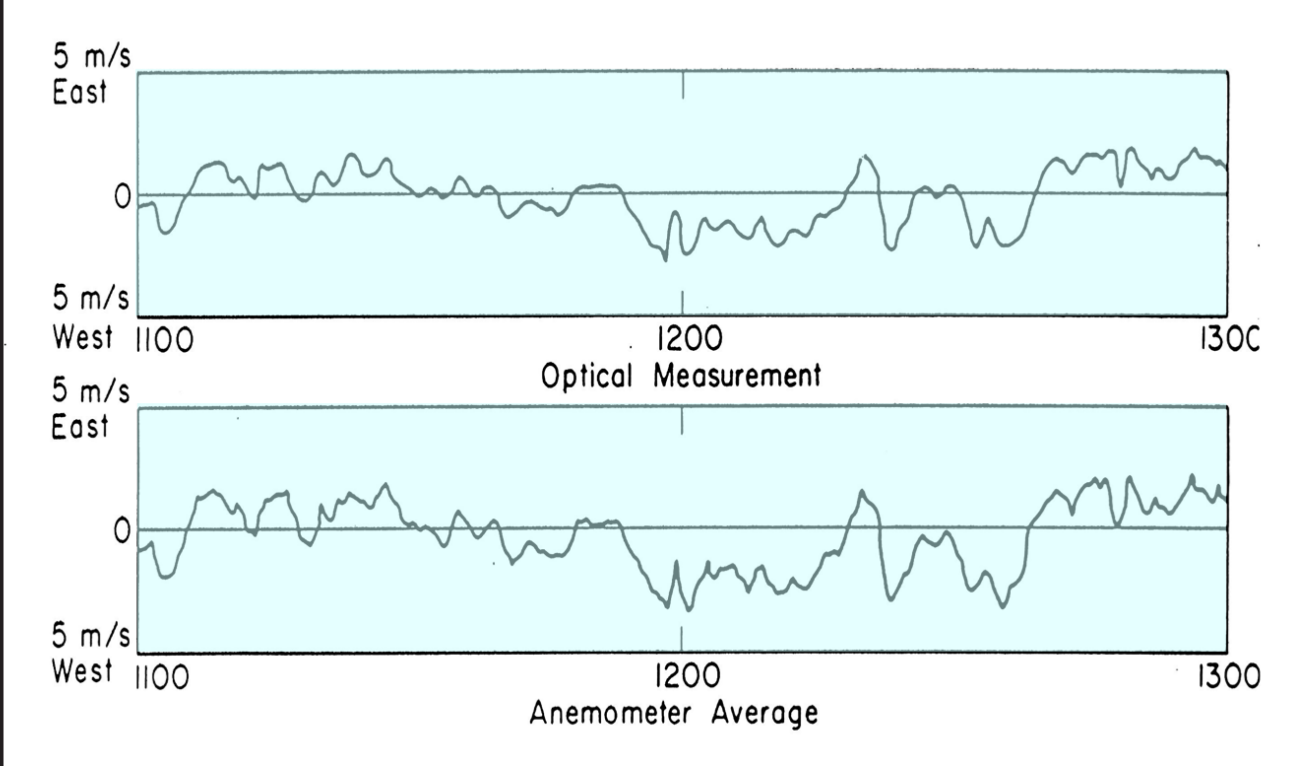
- Long history / proven track record in optical remote sensing
- Used over 30 years for measuring crosswinds & turbulence
- Atmospheric turbulence strength - C_n^2
    - Of interest to laser weapons / optical communications communities
- 1st production sensor; Long-baseline Optical Anemometer (LOA)
    - Scintillation technology applied to longer paths (up to 10km)
    - Used extensively in aluminum smelting operations
    - Scaled down for use in ducts, pipes & smoke-stacks (OFS)
- LOA approved by EPA for method 14 emissions monitoring

Early LOA – Range 100m to 10Km

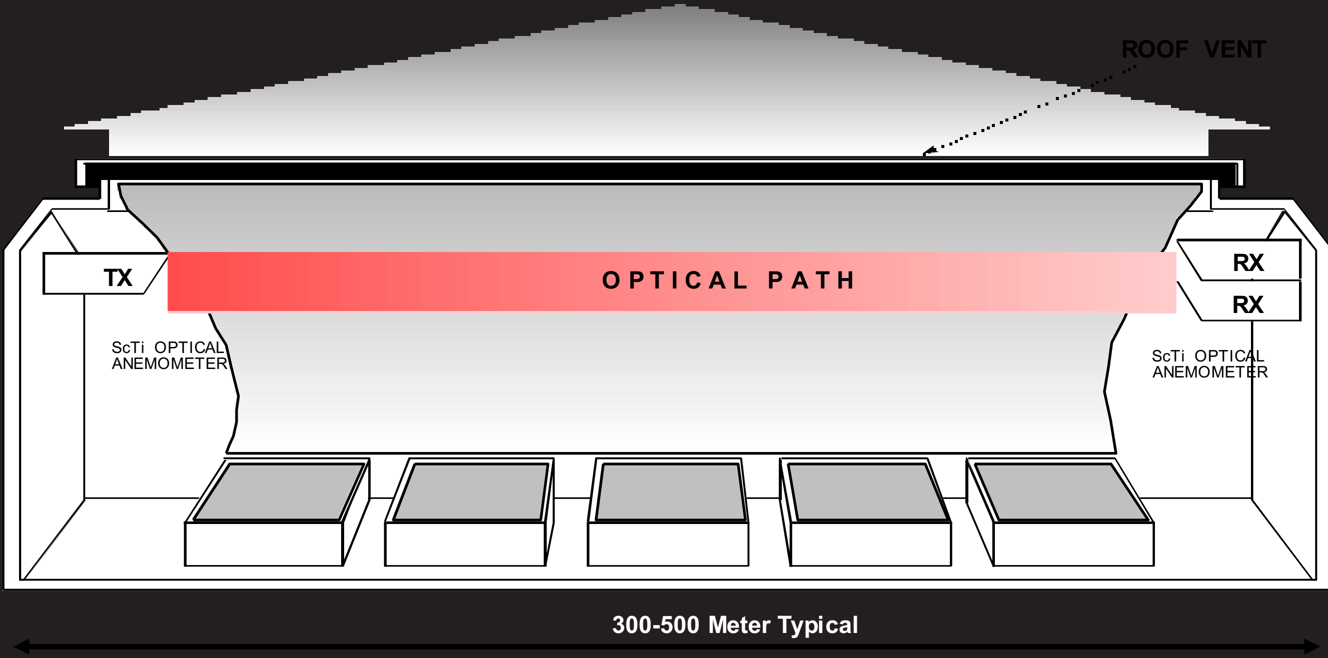
LOA / OWV Block Diagram



LOA Test at Table Mountain, Colorado



LOA for Aluminum Smelters



OPTICAL ANEMOMETER AS USED IN PRIMARY ALUMINUM SMELTER

Aluminum Roof Vents

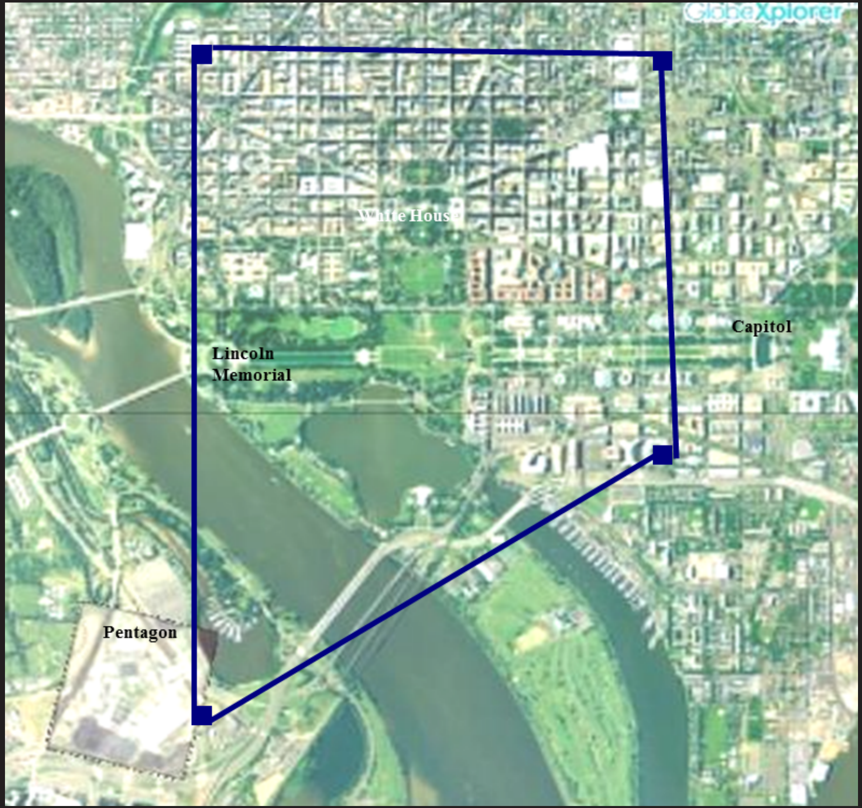
“Keep the sensor out of the harsh environment!”

- Spatially path-averaged measurement of flow; up to 1 Km or more
- Not directly exposed to the effluent
- EPA Method 14 Equivalency Approval
  - LOA sensor & calibrator designed to EPA standards
  - Continuous self test for light level and other parameters
  - HF resistant polycarbonate windows
  - Air knife built into Pneumatic & Alignment Apparatus

Surround the Area of Concern

Capabilities

- Wind and turbulence field
- Shoot over water
- Create 3D wind profiles
- Convergence & Divergence
- Much more accurate than point sensors
- Spatially averaged measure-ment is more representative of the actual wind & turbulence
- Facility; critical area (homeland security)



Fence-Line Wind

- True fence line measurement
- Cross wind is path averaged
- Use two sensors for two dimensional wind profile
- Combine w/ FTIR, DOAS or TDL
- Use three or more sensors to surround facility

Pollution Induced Visibility

Transmissometer

- Laser based
- Hard to align
- Dust/rain/ice affect optics
- Slight change in light affects reading
- High maintenance

Forward Scatter

- LED or Flash tube based
- Dust/rain/ice affect optics
- Slight change in light effect readings
- Mod. maintenance

LOA

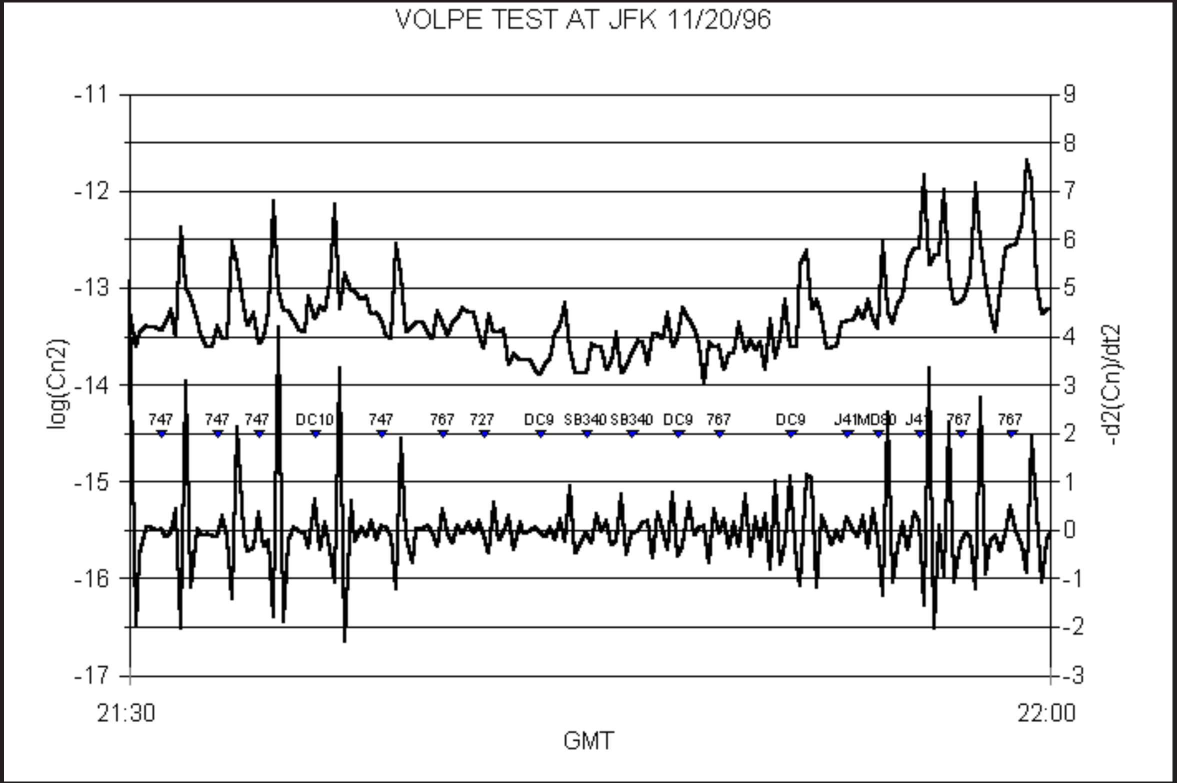
- IRED (InfraRed LED)
- Baseline adapts to rain/dust/ice on optics
- Insensitive to slow changes of light
- Uses scintillation & optical attenuation
- Low maintenance

SCAQMD Landfill Test Site

- Direct method used LOA w/ Spectrometer to calculate mass emissions
- Direct method showed lower mass emissions rate for NH3 and CH4
- Using an array of point wind sensors is difficult if not impossible in practice
- Winds are seldom constant
- Test used two optical flow sensors to indicate when a significant change in wind happened (OFS - OWV - LOA)

LOA Setup at JFK International Airport

Wake Vortex Study Using LOA



Technology Characteristics

- Sensors not sensitive to dirty optics / high opacity media
  - Looking at relative fluctuations in light, not absolute intensity
  - Works well even with a couple percent of light getting thru
- Sensors non-intrusive to media flow
  - Very low maintenance requirements - no clogging
  - Can be used in extremely high or low media temperatures
- Measurement is true line average - more representative
- Automatic daily calibration (programmable or user controlled)
- Continuous self-test / performance monitoring
- Unaffected by temperature, pressure, humidity, density, path length, turbulent flow, etc.
- Easy to install - simple to operate - "plug-n-play"
- DSP-based design: no electronic drift, no periodic recalibration

Technology Advantages

- Path-averaged highly representative measurement
- Mature, well-proven technology
- Versatile technology - fits a wide variety of applications
- “Pure” measurement - not affected by other parameters
- Highly reliable / calibration-free DSP-based implementation
- Low cost, low maintenance
- Low starting threshold, high dynamic range wind measurement

LOA-105/-005 Users List (100+)

- TRW
- US Army Aberdeen Proving Grounds
- Comalco – Bell Bay (Australia)
- Air Fiber Inc.
- ALCOA Europe Aviles (Spain)
- ALCOA Europe La Coruna (Spain)
- Kaiser Aluminum
- ALCOA Badin ALCOA Rockdale Vanalco
- ALCOA, Wenatchee
- Reynolds Longview ALCOA Massena
- US Army Advanced Research Lab, Aberdeen
- University of Maryland
- US Army Fort Belvoir Met Team
- US Army Redstone Arsenal
- Reynolds Massena
- Defense Research Establishment (Canada)
- US EPA Research Triangle Park
- ALCAN Alma Canada
- Naval Research Laboratory
- Norsk Hydro (Norway) NASA Langley
- ALCOA Baie-Comeau (Canada)

References

Wind Velocity and Convergence Measurements at the Boulder Atmospheric Observatory Using Path-Averaged Optical Wind Sensors

MU-KING TSAY,[1] TING-I WANG, R. S. LAWRENCE, G. R. OCHS AND R. B. FRITZ

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Inland Empire Composting Site Emission Test Result Using Optical Flow Sensor and Laser Based Open-Path Spectrometer

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