



Visible Emission Management Using Best Available Technology

The Digital Opacity Compliance System
Second Generation (DOCS II):

International Petroleum Environmental
Conference

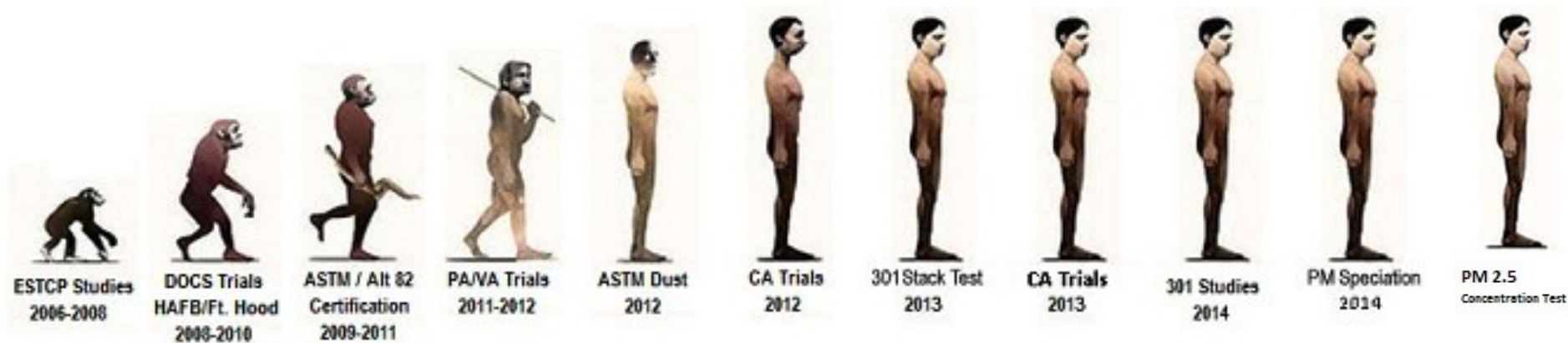
October 7, 2019

Air and Noise Emissions

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Evolution of DOCS II (2006-2016)

Evolution of DOCSII...The Road to SaaS



DOCS

DOCS II

DOCS II Web

DOCS II SaaS

DOCS III SaaS



Evolution of DOCS II

- 2000 to 2005 – Several research projects contracted by DOD & Universities
 - EPA Technology Transfer Network, Emission Technology Center Publishes PRE-008 - Determination of Visible Emissions Opacity from Stationary Sources Using Computer-based Photographic Analysis Systems
- 2005 to 2009 – Research continued by DOD
 - 2007 - ASTM Workgroup formed due to EPA consensus standard direction
 - 2009 - ASTM D7520-09 approved and published
- 2012 February – EPA Office of Air Quality Planning and Standards published US EPA Alternate Method 082 (ALT 082) in the Federal Register as a **Broadly Applicable Standard**, citing ALT 082 certified Digital Camera Opacity Techniques (DCOTs) can be used “in lieu” of Method 9, for all subparts of 40 CFR 60, 61 and 63
 - Federal Permit changes not required
 - Match ASTM D7520
 - Stationary, Mobile, Fugitive

US EPA ALT 082 Broadly Applicable Standard



Evolution of DOCS II Continued

- 2012 October – ASTM D7520-13 Update Approved by ASTM
 - Allows use of any Digital Image Device: High Definition Digital Recorders (Digital Video), (Cell Phones), all Sony CCD based Cameras (98% of Digital Cameras)
 - Allows certification of optical and digital zoom
- 2012 to Present – Fugitive Dust Applicability
 - Original research performed June 05' - June 11'
 - Full NIST Long Path Trans. certification completed January 2012
 - ASTM Research Report submitted to committee July 2012
 - Applicable to fugitives per 40 CFR 60 Subpart 000 October 2012
- 2013 – 301 Testing began to eliminate 7' ASTM stack exit limit
 - EPA desired “comparison with current compliance method”
 - Results ALT 082 is the same as Method 9 observers on stack exits greater than 7'.
- 2015- EPA opinion “Any Creditable Evidence” rule of Clean Air Act, makes applicable to all sources types “a picture says a thousand words”.
- 2015- FerroAlloy NESAP defines DCOT as BACT, and mandates for Process Fugitive Emis.
- 2016 – ASTM D7520-16 Approved no limits on Applicability. Stationary, Mobile, Fugitive
- 2017 – FerroAlloy NESHAP final reconsideration ruling DCOT is BACT for Opacity.

DOCS II is the only ASTM D7520-16 & ALT 082 certified DCOT

DOCS II Global Acceptance

The Nations of the World



1994 MAGELLAN GeographicSM Santa Barbara, CA (800) 929-4MAP

Robinson Projection

**World Bank Requires, <20% Opacity Guarantee for Payment
ASTM D7520-16, used for World Bank Opacity Measurement**



Leading Organizations in Conservation, Compliance, Sustainability, Training
 Regulatory Policy and Enforcement, Local and International, all Agree
Digital Image Based Monitoring is the Way to GO

FAMILIES FOR CLEAN AIR



ArcelorMittal



Industrial Technology
 Institute
 Sri Lanka

California Environmental Protection Agency
Air Resources Board



KINDER MORGAN

Digital Image Based Analysis, The "Best" Solution ⁵

DOCS II Procedure

Send for Analysis

Capture



Transfer images automatically or manually



Receive Validated Digital Report

WIND EMISSION OBSERVATION FORM										
Station	Device	Equipment	Camera and Weather Information							
101	Wind	Model: 10100000000000000000	Camera: Model: 10100000000000000000	Weather: Model: 10100000000000000000	10/10/2010	10:10	10100000000000000000	10100000000000000000	10100000000000000000	10100000000000000000
102	Wind	Model: 10100000000000000000	Camera: Model: 10100000000000000000	Weather: Model: 10100000000000000000	10/10/2010	10:10	10100000000000000000	10100000000000000000	10100000000000000000	10100000000000000000
103	Wind	Model: 10100000000000000000	Camera: Model: 10100000000000000000	Weather: Model: 10100000000000000000	10/10/2010	10:10	10100000000000000000	10100000000000000000	10100000000000000000	10100000000000000000
104	Wind	Model: 10100000000000000000	Camera: Model: 10100000000000000000	Weather: Model: 10100000000000000000	10/10/2010	10:10	10100000000000000000	10100000000000000000	10100000000000000000	10100000000000000000
105	Wind	Model: 10100000000000000000	Camera: Model: 10100000000000000000	Weather: Model: 10100000000000000000	10/10/2010	10:10	10100000000000000000	10100000000000000000	10100000000000000000	10100000000000000000
106	Wind	Model: 10100000000000000000	Camera: Model: 10100000000000000000	Weather: Model: 10100000000000000000	10/10/2010	10:10	10100000000000000000	10100000000000000000	10100000000000000000	10100000000000000000
107	Wind	Model: 10100000000000000000	Camera: Model: 10100000000000000000	Weather: Model: 10100000000000000000	10/10/2010	10:10	10100000000000000000	10100000000000000000	10100000000000000000	10100000000000000000
108	Wind	Model: 10100000000000000000	Camera: Model: 10100000000000000000	Weather: Model: 10100000000000000000	10/10/2010	10:10	10100000000000000000	10100000000000000000	10100000000000000000	10100000000000000000
109	Wind	Model: 10100000000000000000	Camera: Model: 10100000000000000000	Weather: Model: 10100000000000000000	10/10/2010	10:10	10100000000000000000	10100000000000000000	10100000000000000000	10100000000000000000
110	Wind	Model: 10100000000000000000	Camera: Model: 10100000000000000000	Weather: Model: 10100000000000000000	10/10/2010	10:10	10100000000000000000	10100000000000000000	10100000000000000000	10100000000000000000



DOCS II Compared to Humans

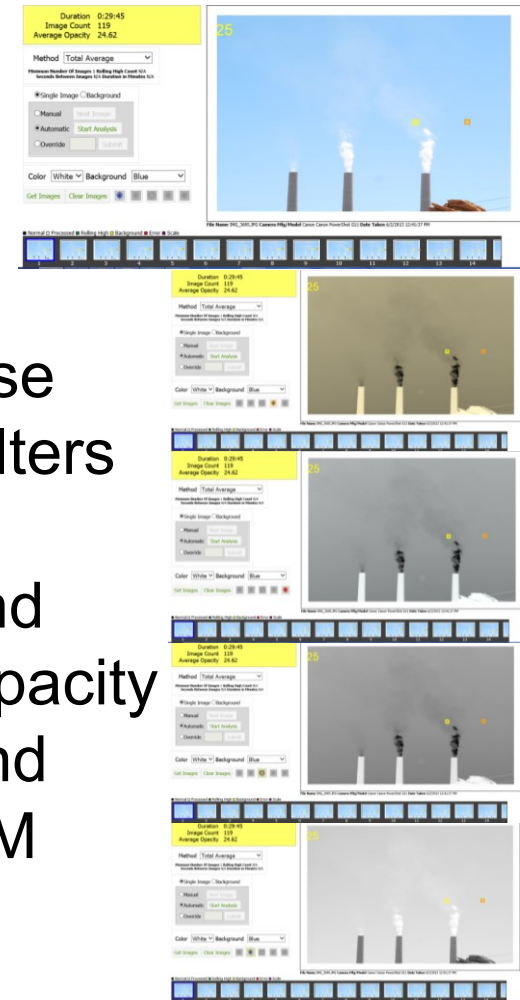
- Less variation than Method 9 against NIST traceable transmissometer
 - Average deviation count for students at CARB certification is 23
 - Typical deviation count for DOCS II on same certification run is 15
 - Over 95% of DOCS II readings were zero or 1 deviation count
- Average deviation under ideal conditions (high contrast)
 - DOCS II $\pm 5\%$
 - Method 9 $\pm 10\%$
- Average deviation under difficult conditions (low contrast)
 - DOCS II $\pm 10\%$
 - Method 9 $\pm 15\%$
- Flexible applicability
 - Clouds, Rain, Snow, Trees, & Buildings
 - Day or Night
 - Close & Far (Limited only by camera zoom)

Simple, Fast, Reliable, Repeatable

How DOCS II Works

- An image or images of the emission source are captured by a certified Camera Operator using a certified camera
- The images are uploaded to the “Cloud” where they are acquired by a Certified Analyst who identifies the Regions of Interest (marked according to explicit rules and training)
- DOCS II then applies algorithms to the Regions of Interest and calculates the opacity of each image and the average, based on the selected rule, e.g. 6 min. avg., 3 min. avg.
- DOCS II generates a draft VEE report
- Source owner accepts and/or rejects the draft VEE report
- DOCS II generates final VEE report and archive record

Use Filters to find Opacity and PM



Simple, Fast, Reliable, Repeatable



Products Available

Regulatory Compliance, Community Conservation



Observation Analysis



Software As a Service

Observation Analysis



MPG/JPG
VEE Process

MPG/JPG
VEE Manage

Obs.
Event
Trans
for
Analysis

Electronic Complaints



Visible Emission Observation Form	Image	Severity	Coordinates	Camera and Weather Information
		1	33.010000, -111.625000	Camera: HighPoint Camera/Canon PowerShot G11 Weather: Wind Speed: 0, Wind Direction: N, Humidity: 21, Temp: 63, Wet Bulb Temp: 22, Precip: 0
		1	33.010000, -111.625000	Camera: HighPoint Camera/Canon PowerShot G11 Weather: Wind Speed: 0, Wind Direction: N, Humidity: 21, Temp: 63, Wet Bulb Temp: 22, Precip: 0
		1	33.010000, -111.625000	Camera: HighPoint Camera/Canon PowerShot G11 Weather: Wind Speed: 0, Wind Direction: N, Humidity: 21, Temp: 63, Wet Bulb Temp: 22, Precip: 0
		1	33.010000, -111.625000	Camera: HighPoint Camera/Canon PowerShot G11 Weather: Wind Speed: 0, Wind Direction: N, Humidity: 21, Temp: 63, Wet Bulb Temp: 22, Precip: 0
		1	33.010000, -111.625000	Camera: HighPoint Camera/Canon PowerShot G11 Weather: Wind Speed: 0, Wind Direction: N, Humidity: 21, Temp: 63, Wet Bulb Temp: 22, Precip: 0
		1	33.010000, -111.625000	Camera: HighPoint Camera/Canon PowerShot G11 Weather: Wind Speed: 0, Wind Direction: N, Humidity: 21, Temp: 63, Wet Bulb Temp: 22, Precip: 0
		1	33.010000, -111.625000	Camera: HighPoint Camera/Canon PowerShot G11 Weather: Wind Speed: 0, Wind Direction: N, Humidity: 21, Temp: 63, Wet Bulb Temp: 22, Precip: 0
		1	33.010000, -111.625000	Camera: HighPoint Camera/Canon PowerShot G11 Weather: Wind Speed: 0, Wind Direction: N, Humidity: 21, Temp: 63, Wet Bulb Temp: 22, Precip: 0
		1	33.010000, -111.625000	Camera: HighPoint Camera/Canon PowerShot G11 Weather: Wind Speed: 0, Wind Direction: N, Humidity: 21, Temp: 63, Wet Bulb Temp: 22, Precip: 0
		1	33.010000, -111.625000	Camera: HighPoint Camera/Canon PowerShot G11 Weather: Wind Speed: 0, Wind Direction: N, Humidity: 21, Temp: 63, Wet Bulb Temp: 22, Precip: 0

Onsite Observation Switch
Archive Storage

Multi Point
Method 22 Surveys

Electronic VEE Reports

FUGITIVE OR SMOKE EMISSION INSPECTION

OUTDOOR LOCATION

COMPANY: SENSORY
LOCATION: STARR PASS CONVENTION
COMPANY REP: SDD
SKY CONDITION: CLEAR
TEMPERATURE: 63
REL HUMIDITY: 21
INDUSTRY: TOURISM

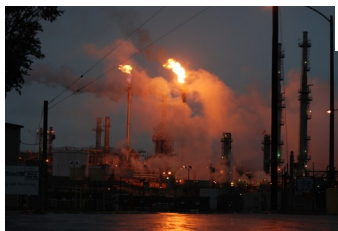
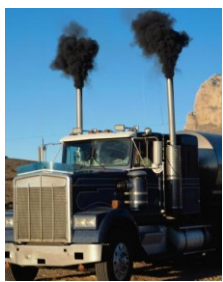
OBSERVER: LINDA RAWSON
AFFILIATION: SENSORY
DATE: 3/27/2018
PRECIPITATION:
WIND SPEED/DIR: 5 W
WET BULB TEMP: 22
PROCESS: N/A

EVENT TIME LIMIT 3

SOURCE ID	SECONDS	IMAGE
AC1	65	
AC2	32	
AC3	0	



LONGITUDE: 111.625111

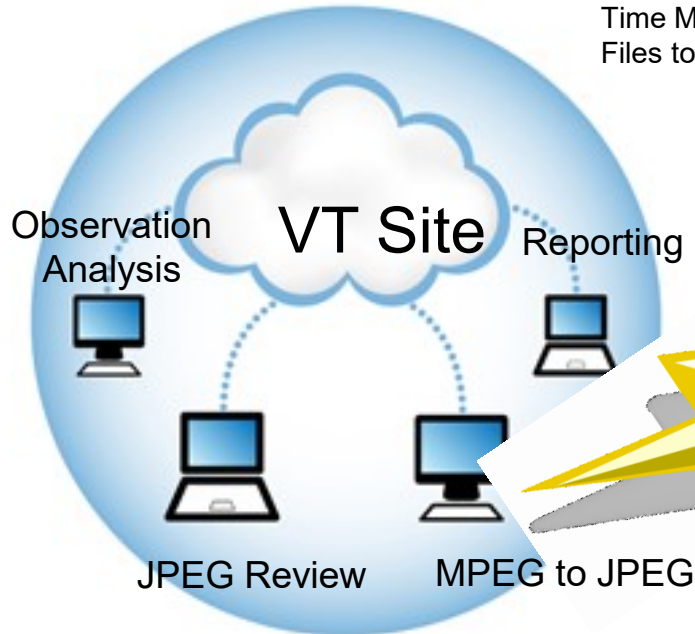




Flare Monitoring System with Opacity Event Reporting

Convert to JPEG every 15 seconds
During marked event times
and display for observation cut down

Time Marked
Files to Cloud



Flare Site

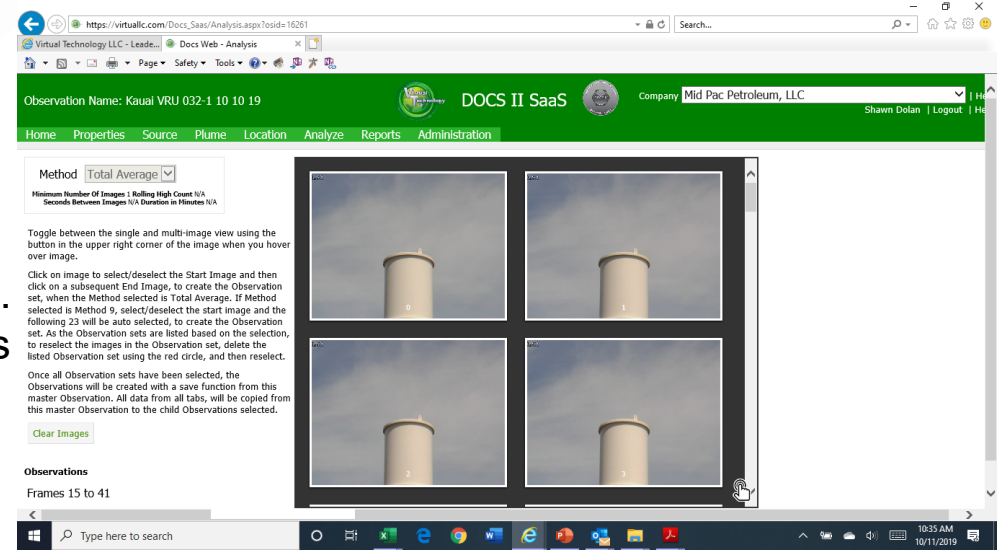
Local Mounted
Intrinsic all weather
Internet Protocol Cam



Local copy of MPG4 "video files"
mirrored high capacity drives, Archived
monthly Time marked by "Control
Operators log" for events.

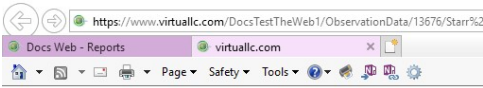


Remote copy of MPEG "video files"
Control Operators log, time marked for events.
Cuts MPEG into JPG at 15 second increments
Extracts JPG sets (Observations)
Runs screening on Observations
Marks observations JPG w opacity.
Generates Monthly and Semi Annual report.





Gas & Oil 0000a Fugitive Emission Survey Opacity Event Reporting



FUGITIVE OR SMOKE EMISSION INSPECTION

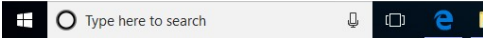
OUTDOOR LOCATION

COMPANY: SENSORY
 LOCATION: STARR PASS CONVENTION
 COMPANY REP: SDD
 SKY CONDITION: CLEAR
 TEMPERATURE: 63
 REL HUMIDITY: 21
 INDUSTRY: TOURISUM

OBSERVER: LINDA RAWSON
 AFFILIATION SENSORY
 DATE: 3/27/2018
 PRECIPITATION:
 WIND SPEED/DIR: 5 W
 WET BULB TEMP: 22
 PROCESS: N/A



LONGITUDE: 111.02.51.970 W
 LATITUDE: 32.12.57.458 N

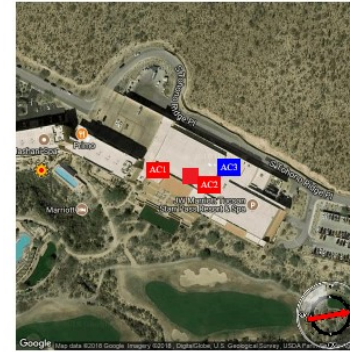


FUGITIVE OR SMOKE EMISSION INSPECTION

OUTDOOR LOCATION

COMPANY: SENSORY
 LOCATION: STARR PASS CONVENTION
 COMPANY REP: SDD
 SKY CONDITION: CLEAR
 TEMPERATURE: 63
 REL HUMIDITY: 21
 INDUSTRY: TOURISUM

OBSERVER: LINDA RAWSON
 AFFILIATION SENSORY
 DATE: 3/27/2018
 PRECIPITATION:
 WIND SPEED/DIR: 5 W
 WET BULB TEMP: 22
 PROCESS: N/A



LONGITUDE: 111.02.51.970 W

EVENT TIME LIMIT 3

SOURCE ID	SECONDS	IMAGE
AC1	65	
AC2	32	
AC3	0	

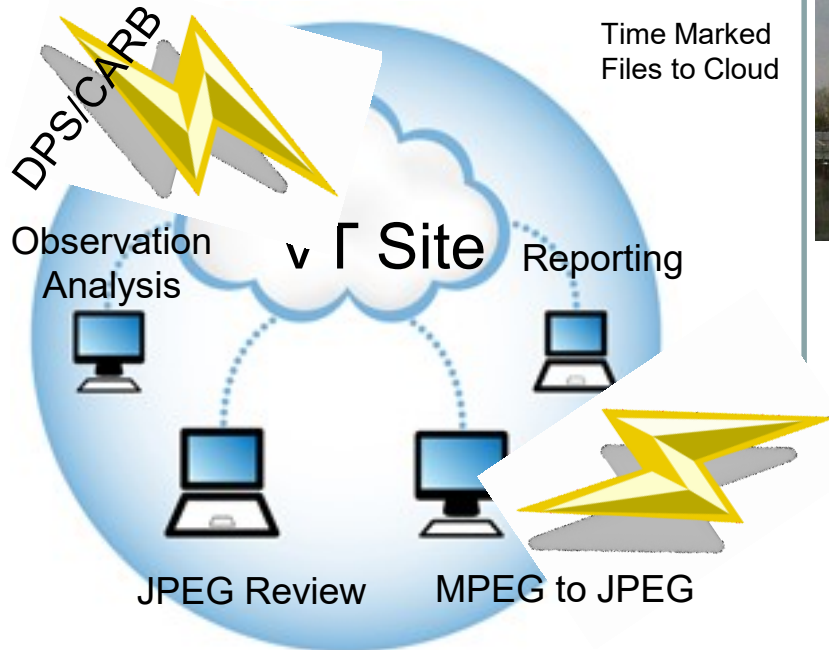
- User drags the emission points from facility onto map.
- Emission Points all start Blue
- User touches each Emission point as they see emissions
- Emission points toggle color Green on Red off
- Clock displays survey time and remaining time
- End of Survey sum totals all on/off events by source and compares to limit
- Generates Survey report listing emission units, visible emission time
- User prompted to record picture of exceeding emission units.



Heavy Duty Vehicle Emissions Enforcement

Convert to JPEG every 15 seconds
During marked event times
and display for observation cut down

Time Marked
Files to Cloud



Enforcement Site



Local Mounted
Intrinsic all weather
Internet Protocol Cam



Local copy of MPG4 "video files"
mirrored high capacity drives, Archived
monthly Time marked by "Control
Operators log" for events.



Remote copy of MPEG "video files"
Plate/Transponder number tag to images.
MP4 into JPG at set interval (reduce storage)
Opacity Analysis on high image (smoke > 5%)
Creates Violation Record (Image, Opacity, Plate/Trans)
Transmits Violation record to ??? For enforcement
Automated Enforcement Close out
Generates monthly follow up report



Coalition For Clean Air Citizen Science

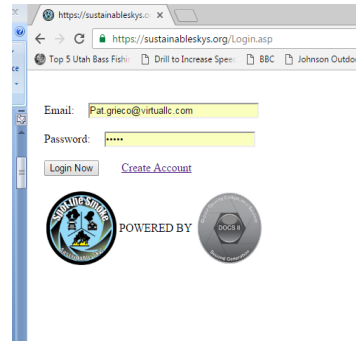
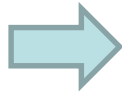
California Assembly Bill

617 Community Air Protection Program Now Law and Funded

Navigate to SustainableSkys.Org

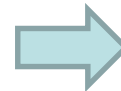
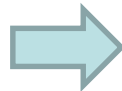
Log In or Create an Account

Submit to create a Draft Report
Submit Draft for Opacity Analysis
Receive Final Report



Touch the Screen to Indicate
Where you are looking

Take or Attach an Existing
Picture



[CLICK HERE for review and opacity determination](#)



2-5 Billion Dollars To Build Community Air Monitoring Infrastructure

Spot the Smoke

CA AB 617 Community Air Protection Program

- Spot the Smoke Released in March 2014 (7 Step)
 - Buggy and did not operate well on iPhone (Safari) platform
 - Revision 2, in June 2015 still has browser compatibility (5 Step)
 - works plug and play 70% of the time.
 - Revision 4, Released January 2017, (3 Step)
- Stationary Sources
 - Requiring Permits, require other compliance monitoring
 - Category people pay to expedite
- Mobile Sources
 - Smaller mobile sources, cars, trucks
 - Requiring frequent licensing
 - Larger mobile sources, planes, trains, ships
 - Reduced licensing frequency
- Fugitive Area Sources
 - Larger sources farms and agriculture
 - Fugitive emissions, largest category of undocumented air pollution
 - Includes Wood Smoke also category people pay to expedite
- Natural Area Sources (spikes during event)
 - Great Dust Storm and Forest Fire Pictures
 - Not predictable

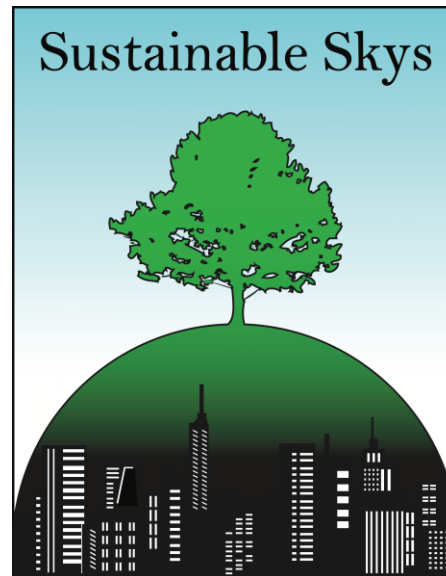


Products Available

Regulatory Compliance, Community, Conservation

- Digital Opacity Compliance System second generation (DOCS II) – Digital Camera Opacity Technique, Software as a Service
- Spot the Smoke – Public Application
- Multi Point Visible Emission Survey Method 22
- Virtual Watch: Stacks, Flares, Vents, HD Vehicles, Continuous Near Real time Opacity Monitoring and PM Concentration Estimates

GAS and Oil MACT ooooo:
If you use a combustion control device, you must also maintain a continuous pilot flame at all times of operation and conduct monthly visible emissions tests. You must conduct the visible emissions test for 15 minutes using EPA Method 22. Devices must be operated with no visible emissions, except for periods not to exceed 1 minute during any 15-minute period. [§ 60.5415a(b)(2)].



**Community Air Protection Program:
Technical Summits -
February 2018**

The California Air Resources Board (CARB) invites you to participate in technical summits on the implementation of the Community Air Protection Program (Program).

Future Now: PM Speciation

- Measuring PM Concentration via Light Scatter & Energy Emittance



Gas Turbine Stack Opacity and PM Sources

Common Sources of Liquid Fuel GT Opacity:

- Acid mist: H_2SO_4 , etc..
 - < 5 ppm H_2SO_4 for 20% opacity
- SO_3 (Blue plume)
 - ~ 10 ppm SO_3
- NO_2 (Yellow plume)
 - ~15 ppm NO_2
- Solid PMs
 - Carbon soot
 - Ash
- Other vapors
- UHCs reactions with NO_x & SO_x (?)
 - Greatly increase NO_2
 - Maybe SO_3
- Mitigations:
 - Stack temperature (SO_x , H_2SO_4)
 - Fuel composition
 - Oxidation catalyst
 - Carbon soot catalyst
 - ESP, Electrostatic Precipitator
 - FGD, Flue Gas Desulfurization
- Measurement:
 - Digital Opacity Meter, EPA 082
 - Human, EPA 9

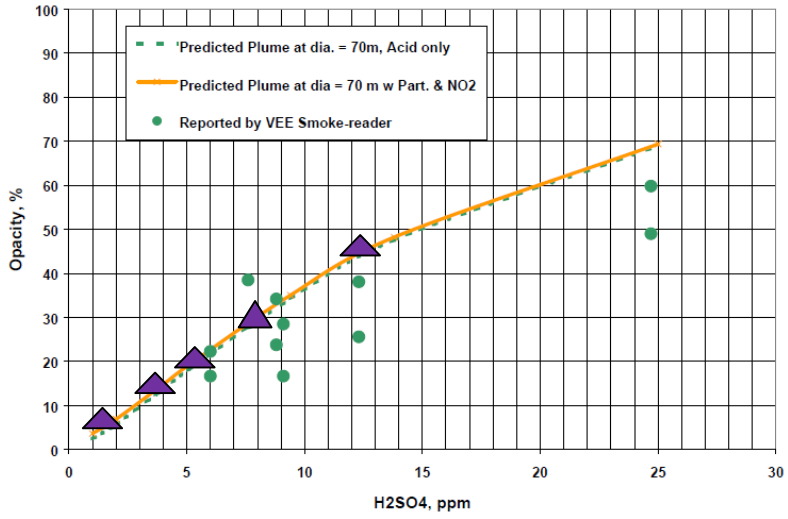


Figure 7.10. Comparison of predicted plume opacities versus H_2SO_4 concentration with those measured by a certified "smoke reader" for a 1300 MW unit with a pollution control system consisting of an SCR followed by a cold-side ESP and an SO_2 scrubber.

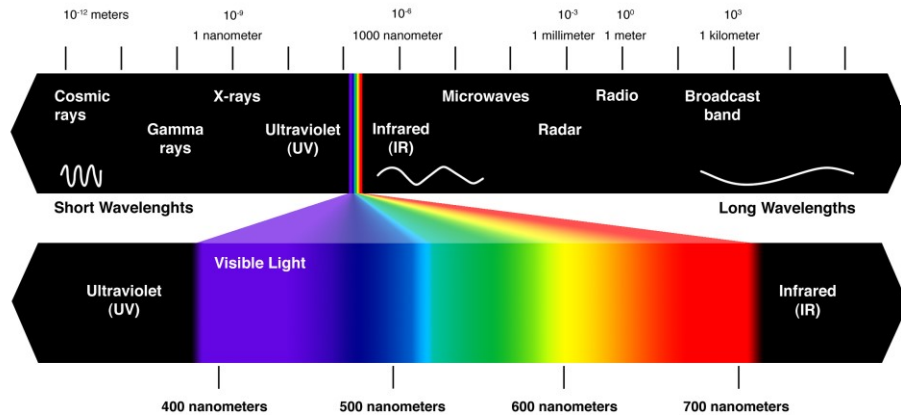
Label is % Opacity

Digital image analysis regions

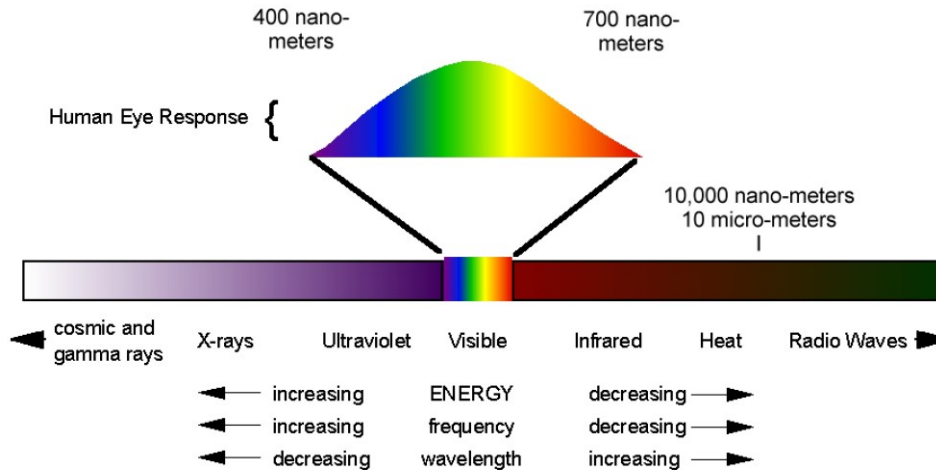
- Plume analysis region
- Background analysis region

Light Wavelength

Sony CCD Based Cameras “see” an wider spectrum than does the human eye, like birds “see” more UV

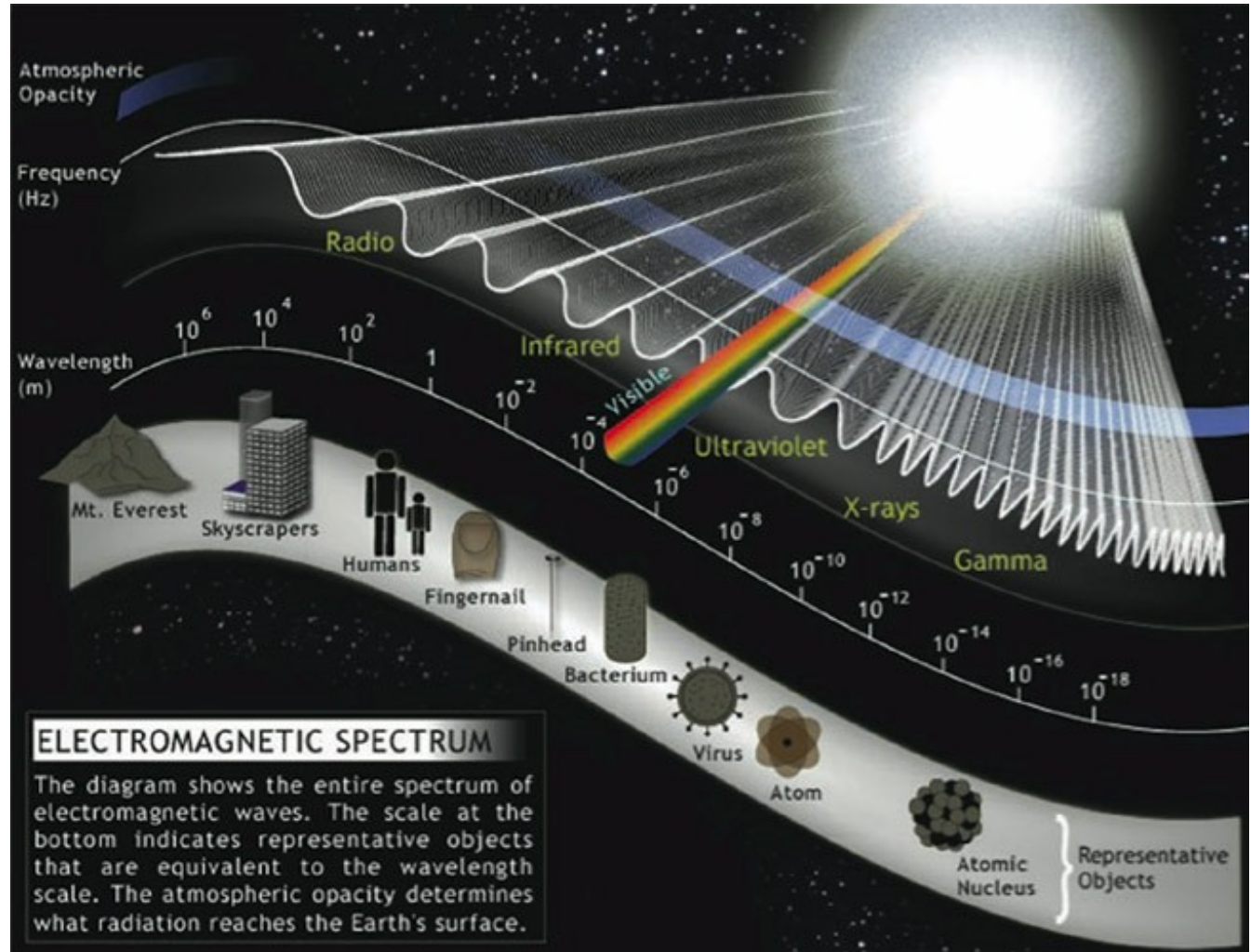
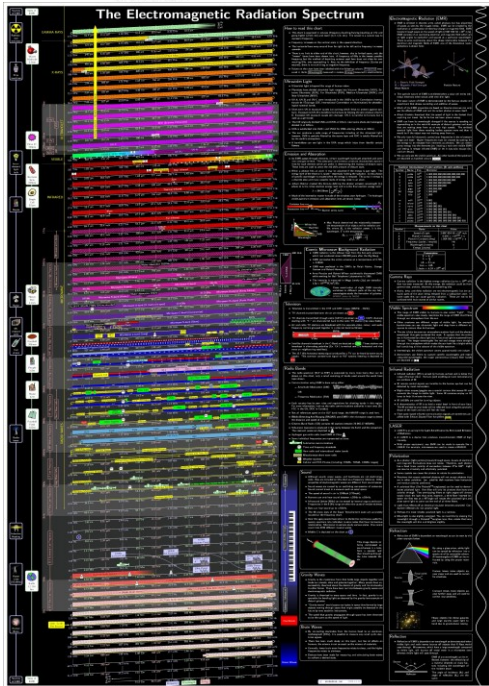
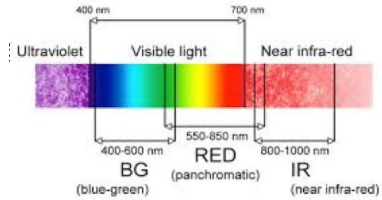


Sony CCD Based Cameras “see” from the non-visible UV to the non-visible IR spectrum and 1080P is dense enough to measure scatter in all directions.



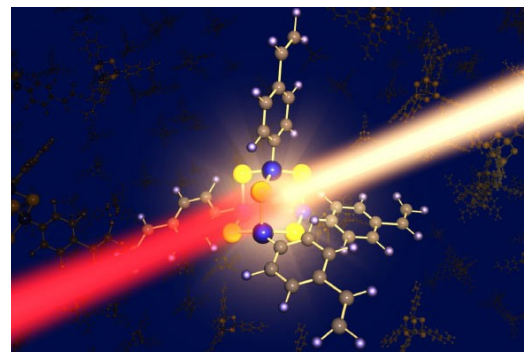
Foundational Physics Principles Universally apply to plumes, e.g. as particle size decreases energy emittance and frequency increase .

All Consumer Cameras Record UV, VL, IR, Spectrums

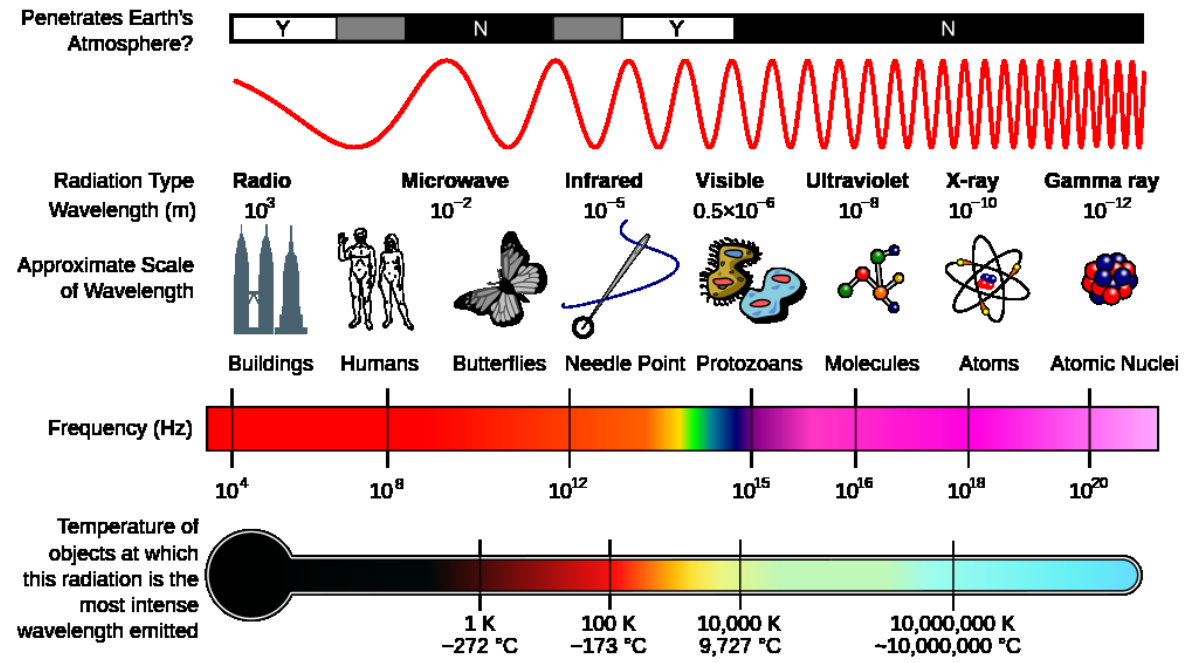


Opacity, blended with UV/VL/IR light generates expected energy profile

Digital Images Contain The Building Blocks



Light Scatter is a well known Measurement Principle, As Particle size = Wave length = known Scatter (LiDAR)



Temperature change measurement is the baseline for all FTIR based Optical Gas Imaging

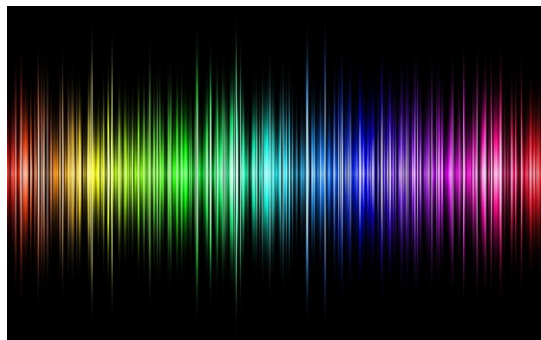
Each Pixel holds the values to measure scatter, temp change

Patent Pending, Opacity/PM Software

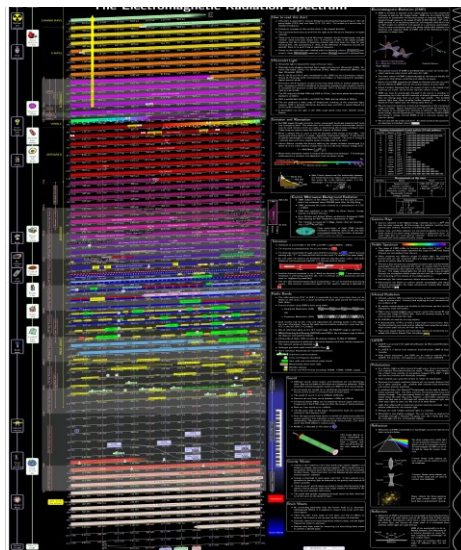
Cameras the human operates



Document Light Scatter the human can not see and

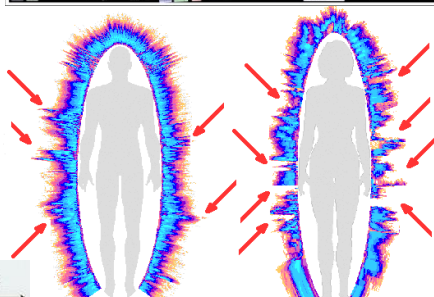


Energy/Intensity Level the human can not feel

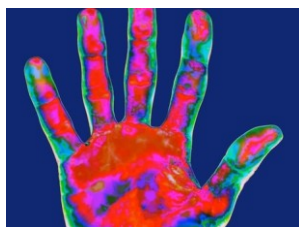


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Temperature delta's the human can not feel



VISIBLE EMISSION OBSERVATION FORM		Observer	Date	Time	Location	Weather	Wind	Temp	Humidity	Pressure	Clouds	Visibility	Remarks
1		10	10/10/2010	10:10 AM	1000	Clear	10	10	10	10	10	10	10
2		10	10/10/2010	10:10 AM	1000	Clear	10	10	10	10	10	10	10
3		10	10/10/2010	10:10 AM	1000	Clear	10	10	10	10	10	10	10
4		10	10/10/2010	10:10 AM	1000	Clear	10	10	10	10	10	10	10
5		10	10/10/2010	10:10 AM	1000	Clear	10	10	10	10	10	10	10
6		10	10/10/2010	10:10 AM	1000	Clear	10	10	10	10	10	10	10
7		10	10/10/2010	10:10 AM	1000	Clear	10	10	10	10	10	10	10
8		10	10/10/2010	10:10 AM	1000	Clear	10	10	10	10	10	10	10
9		10	10/10/2010	10:10 AM	1000	Clear	10	10	10	10	10	10	10
10		10	10/10/2010	10:10 AM	1000	Clear	10	10	10	10	10	10	10

In Selected ROI's

- 30 % Opacity
- PM < 3m @ 20%
- PM 3-7m @ 35%
- PM > 7m @ 45%



Automated Visible Emissions Monitoring and Electronic Reporting of Visible Emission Surveys (Method 22) Opacity Observations (Method 9) Stack/Flare Watch (custom) Heavy Duty Vehicle Emissions (custom)

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801 309 3626