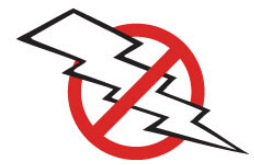




CHARGE TRANSFER TECHNOLOGY

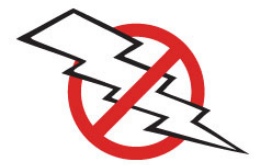
By
Peter Carpenter, Director of Applied Engineering
Lightning Protection Summit, May 2013



INCREASED LIGHTNING

**3 TANK FIRES IN
LESS THEN 2 WEEKS
IN THE GULF COAST REGION**

**IN PAST YEARS
15-20 TANK FIRES PER
YEAR WAS THE NORM
GLOBALLY**

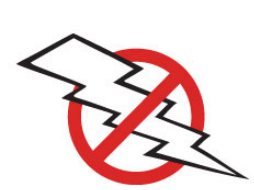


HOUSTON, TX

April 24, 2013

Houston, TX | Southwest Mineral Oil Terminal
Mineral Oil



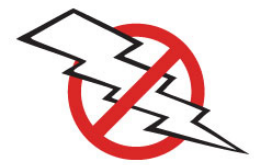


HARRIS COUNTY, TX

April 27, 2013

Harris County, TX | Ft. Worth Natural Gas
Crude Oil



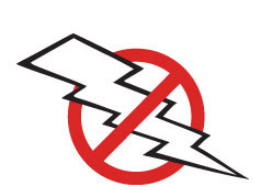


DENHAM SPRINGS, LA

May 2, 2013

Denham Springs, LA | Denbury Resources, Inc
Crude Oil





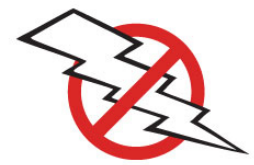
NEW TREND

Fact

In 41 years LEC and our associates have not seen this many tank fires cause by lightning in such a short period of time in the Gulf Coast

Conclusion:

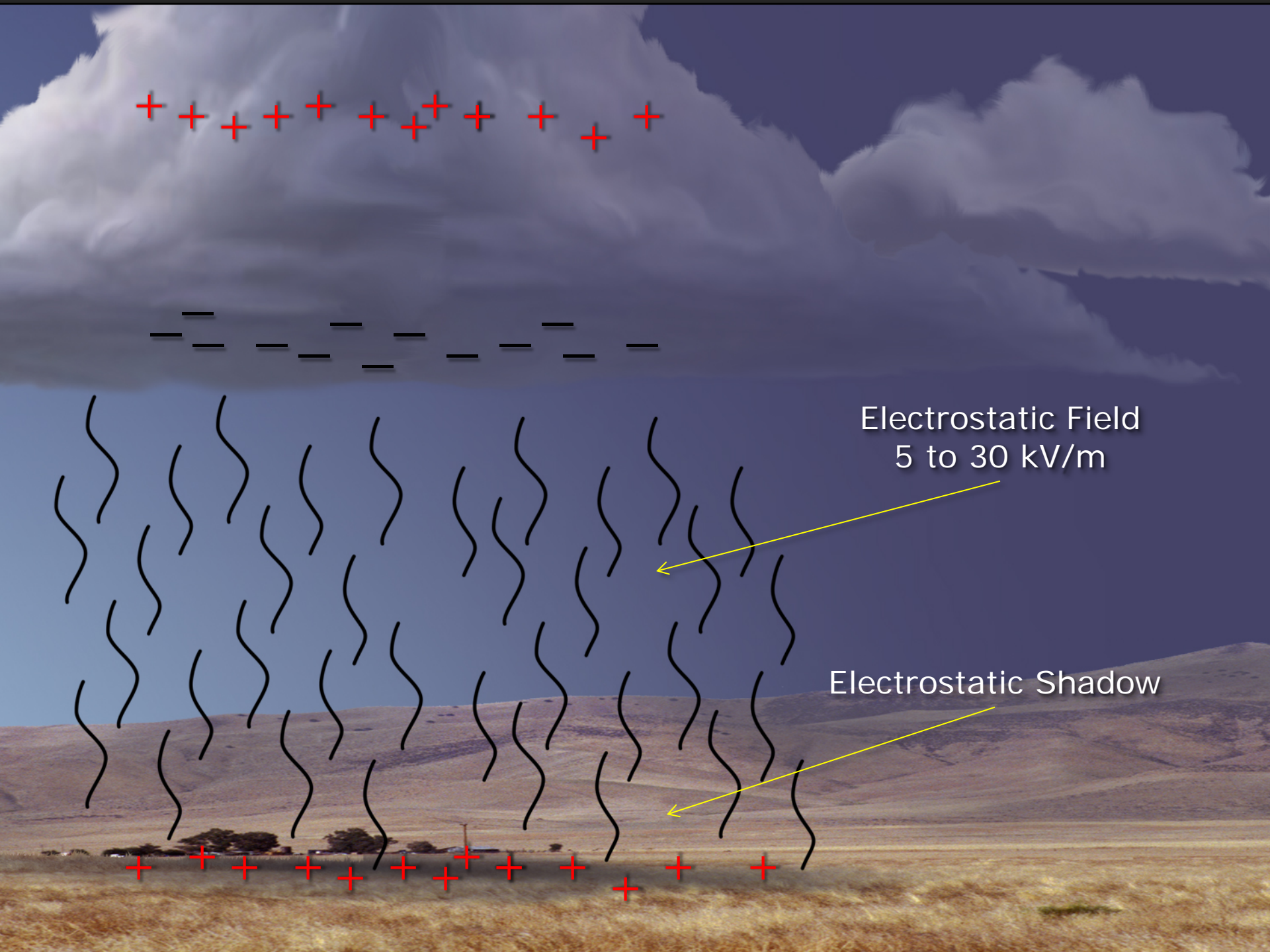
Oil & Gas needs to take proactive measures to be taken to prepare



The Lightning Discharge



Roch Hart, Barcroft / Landov



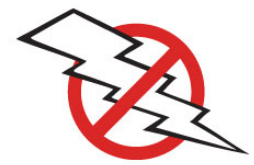
+

-

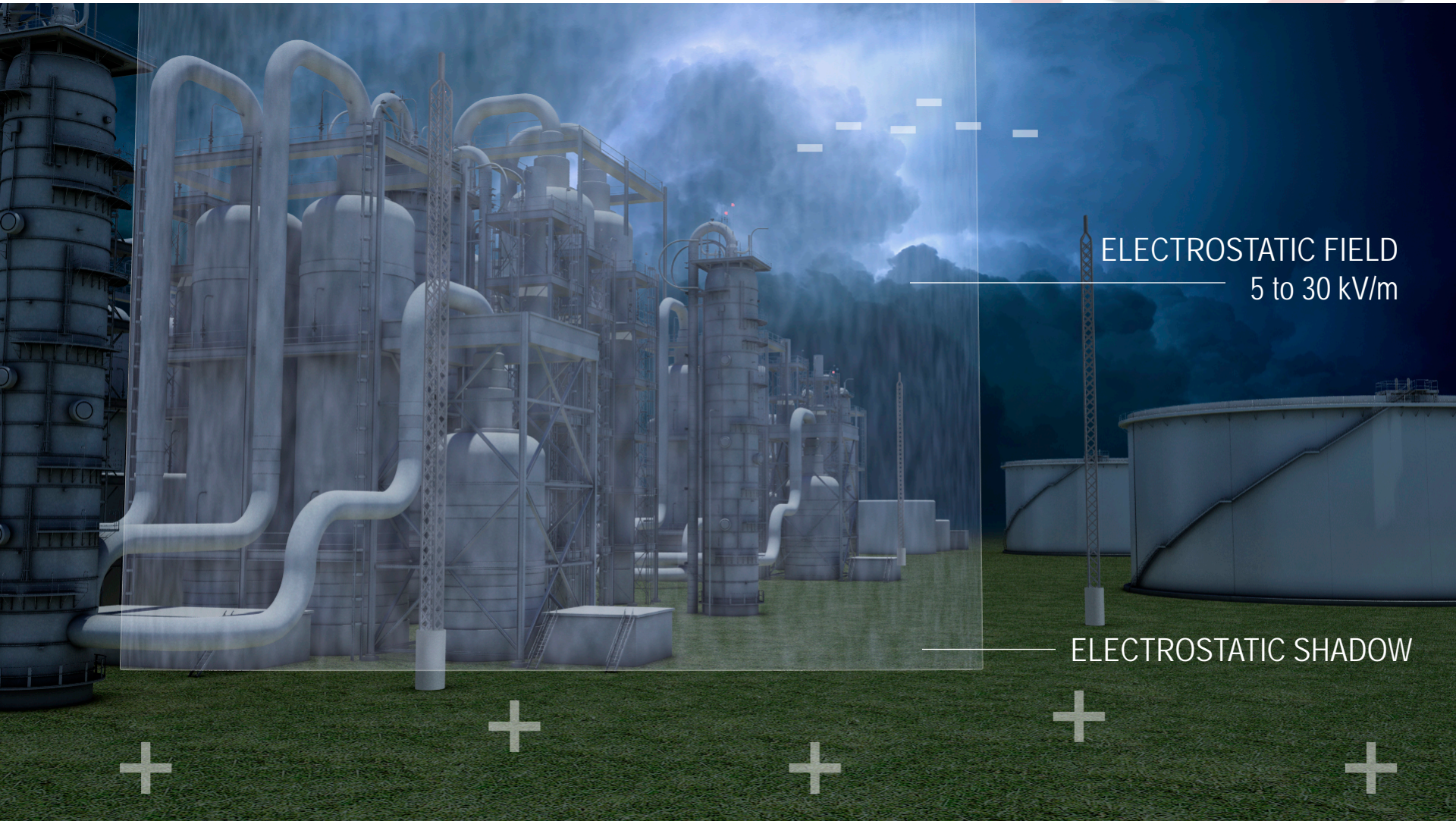
Electrostatic Field
5 to 30 kV/m

Electrostatic Shadow

+

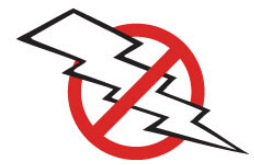


Electrostatic Field



ELECTROSTATIC FIELD
5 to 30 kV/m

ELECTROSTATIC SHADOW

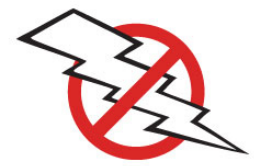


$10^8 \text{ V} \pm 10\%$



$10^8 \text{ V} \pm 10\%$

Copyright ©2013, Lightning Eliminators & Consultants, Inc.

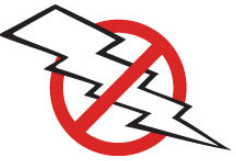


Rising Streamers



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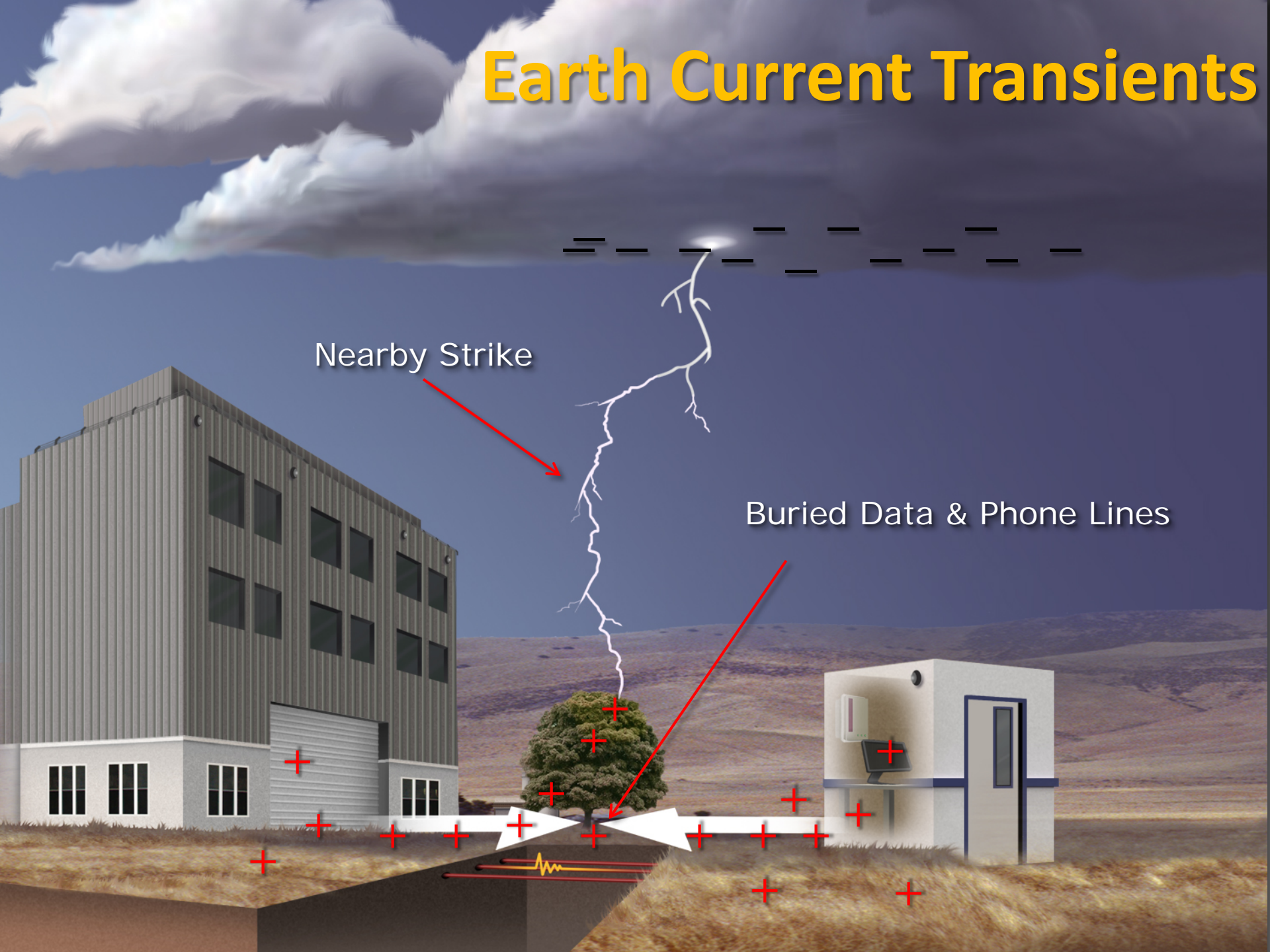
Storm Generated Upward Streamers



Streamers



Earth Current Transients



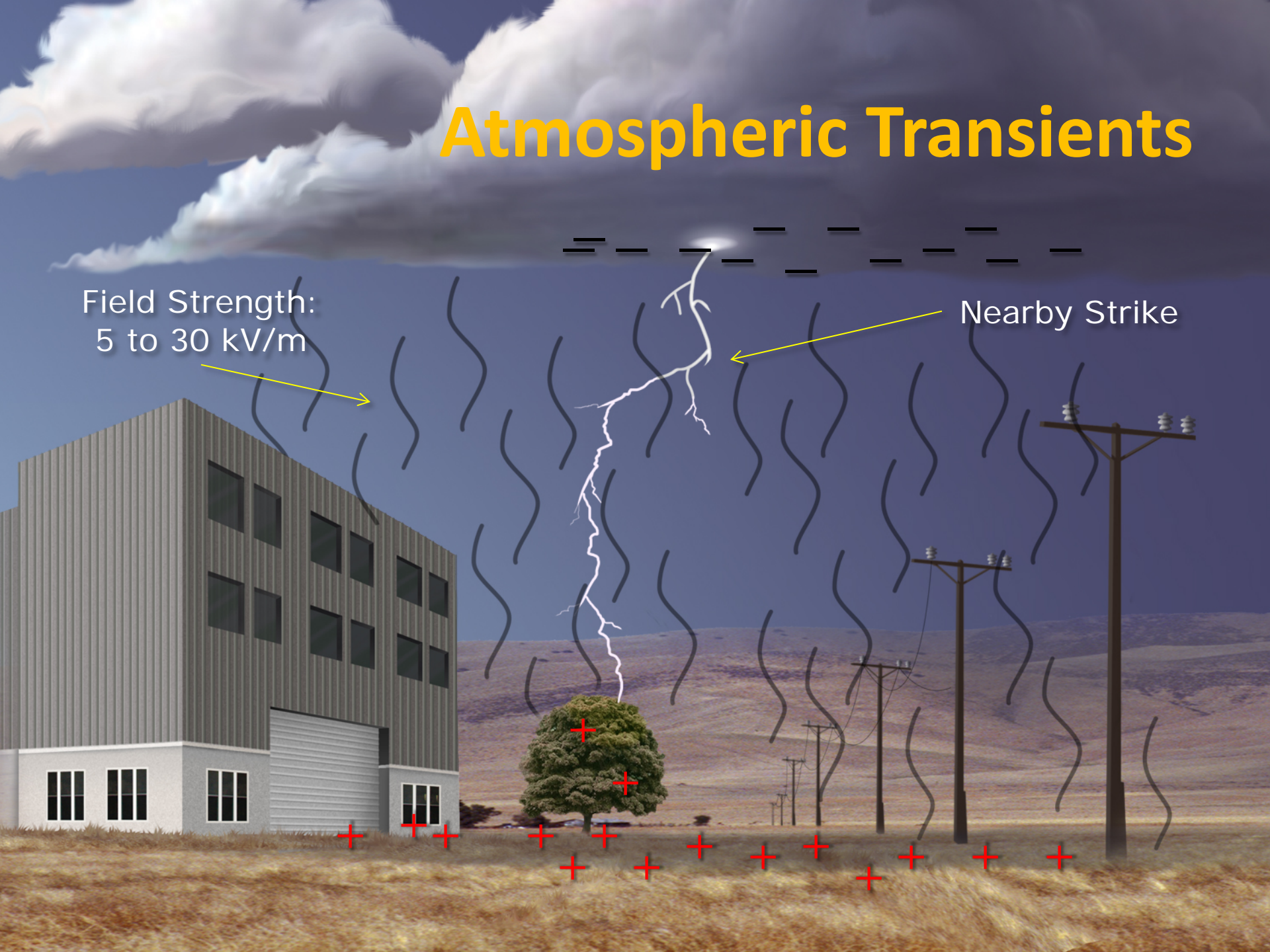
Nearby Strike

Buried Data & Phone Lines

Atmospheric Transients

Field Strength:
5 to 30 kV/m

Nearby Strike



Atmospheric Transients



Overhead Power
& Comm Lines

Atmospheric Transients

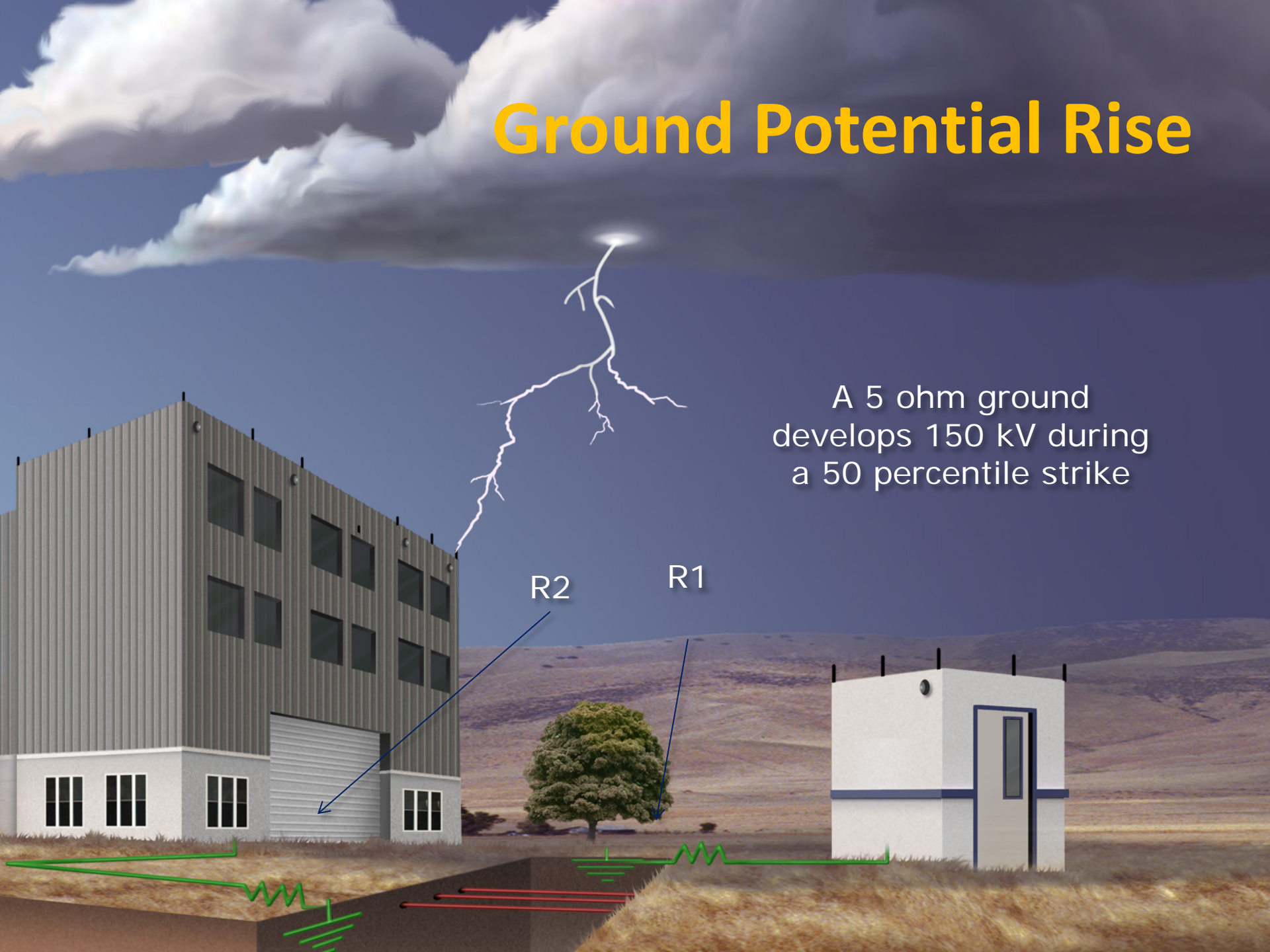


Overhead Power & Communication Lines

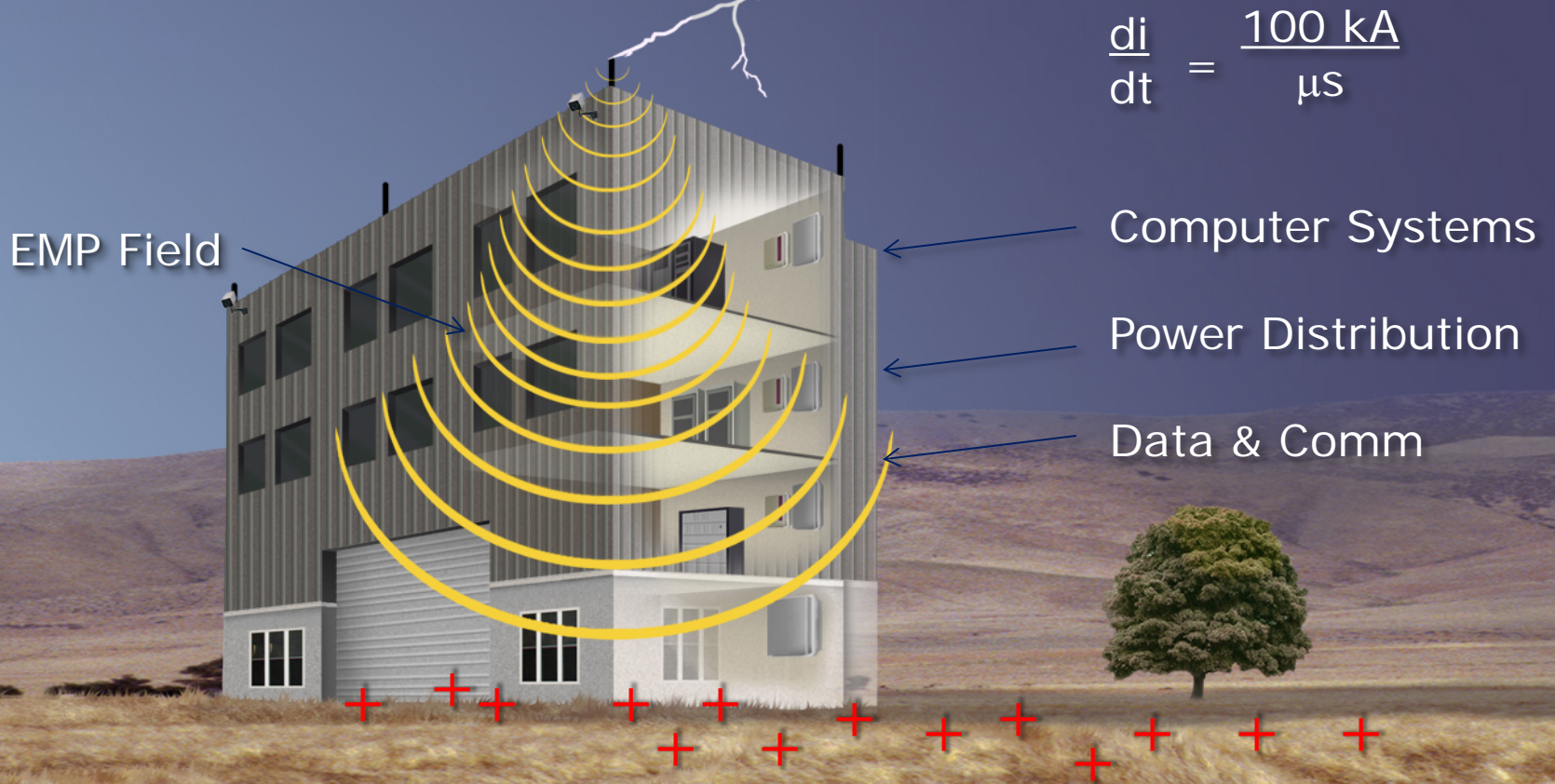


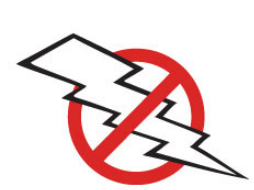
Ground Potential Rise

A 5 ohm ground develops 150 kV during a 50 percentile strike



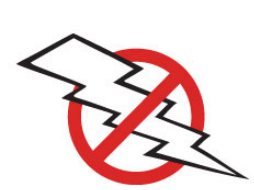
Stroke Channel EMP





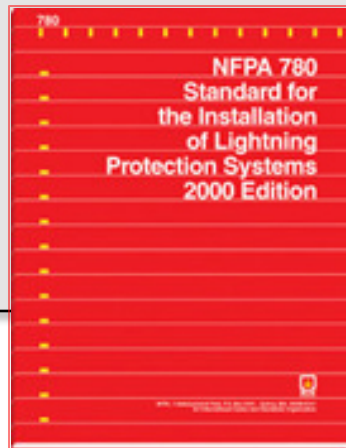
Summary of Secondary Effects

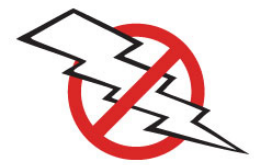
- Earth Current Transients
- Atmospheric Transients
- Electromagnetic Pulse
- Ground Potential Rise



Industry Standards

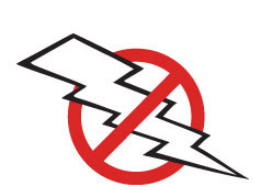
- Over 250 years with no significant changes
- Based on “historical precedent”
- Intended to collect strikes!





Petroleum Tank Fire - Engulfed



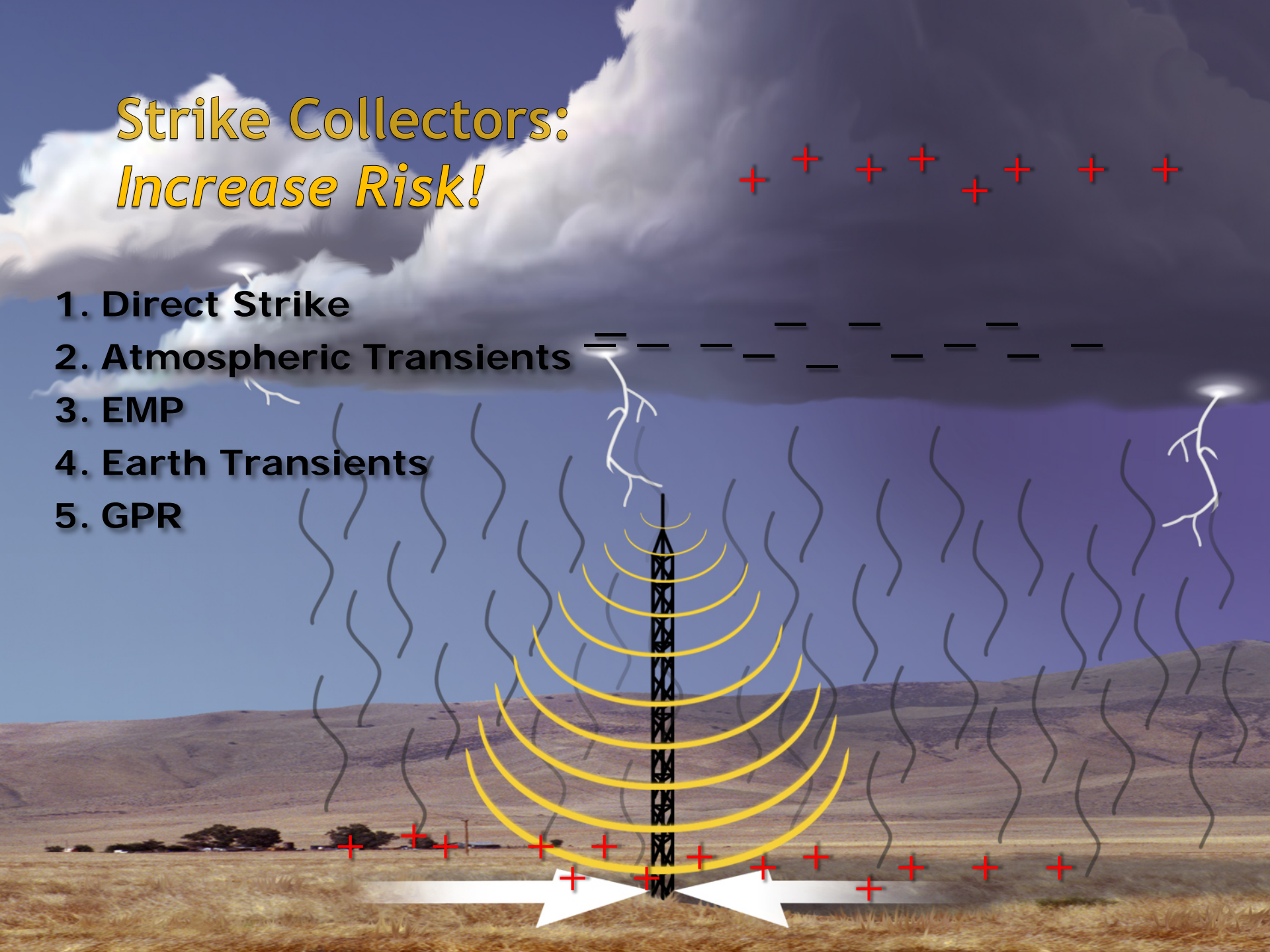


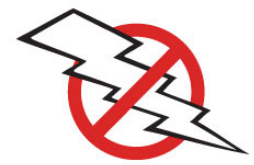
Petroleum Tank Fire - Aftermath



Strike Collectors: *Increase Risk!*

1. Direct Strike
2. Atmospheric Transients
3. EMP
4. Earth Transients
5. GPR



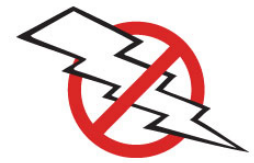


Direct Strike Protection





THE DISSIPATION ARRAY™ SYSTEM (DAS™)



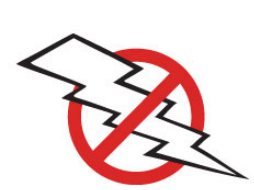
DAS™: PROVEN PERFORMANCE

- In use since 1971
- > 99.87% success rate
- Over 37,000 system years
- Exclusive *No-Strike* warranty



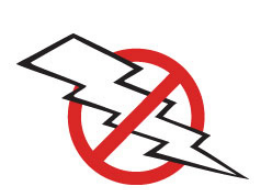
FOUNDATIONAL DEFINITIONS

- Lightning is a discharge
- Discharge transfers charge (Ampere-Seconds)
- DAS is a Charge Transfer System (CTS)
 - CTS: Generic name
 - DAS: LEC's patented Dissipation Array System



THE DAS OBJECTIVE

- Use points to transfer charge slowly and continuously
- Use the storm's electric field as the motivating force (Passive system)



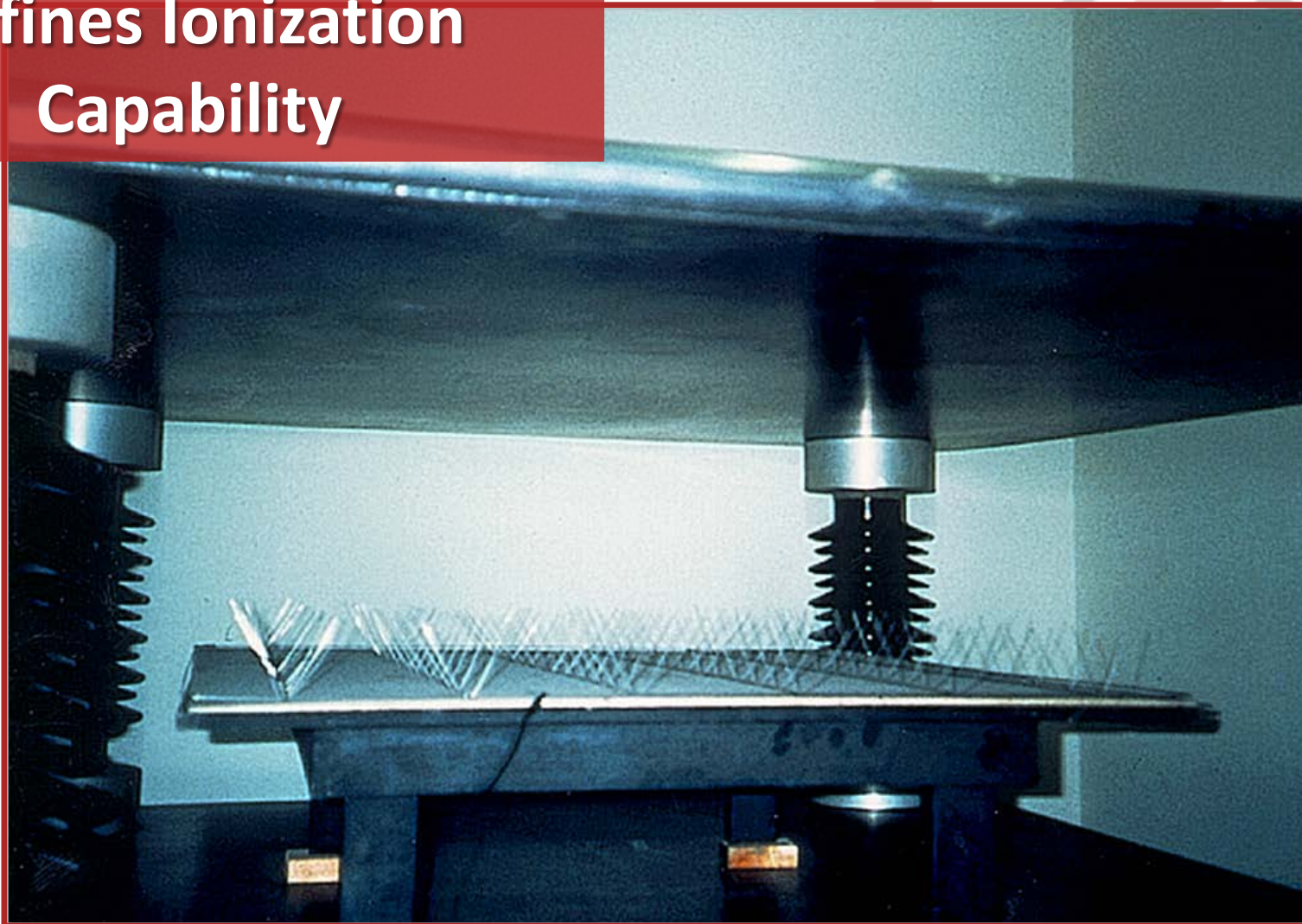
IONIZATION FACTORS

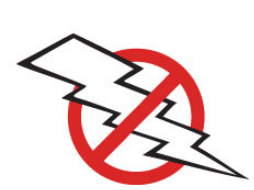
- **Maximum ionization is achieved by optimizing design parameters:**
 - ➔ Point Spacing
 - ➔ Point Length
 - ➔ Number and geometry of points



LEC SIMULATOR

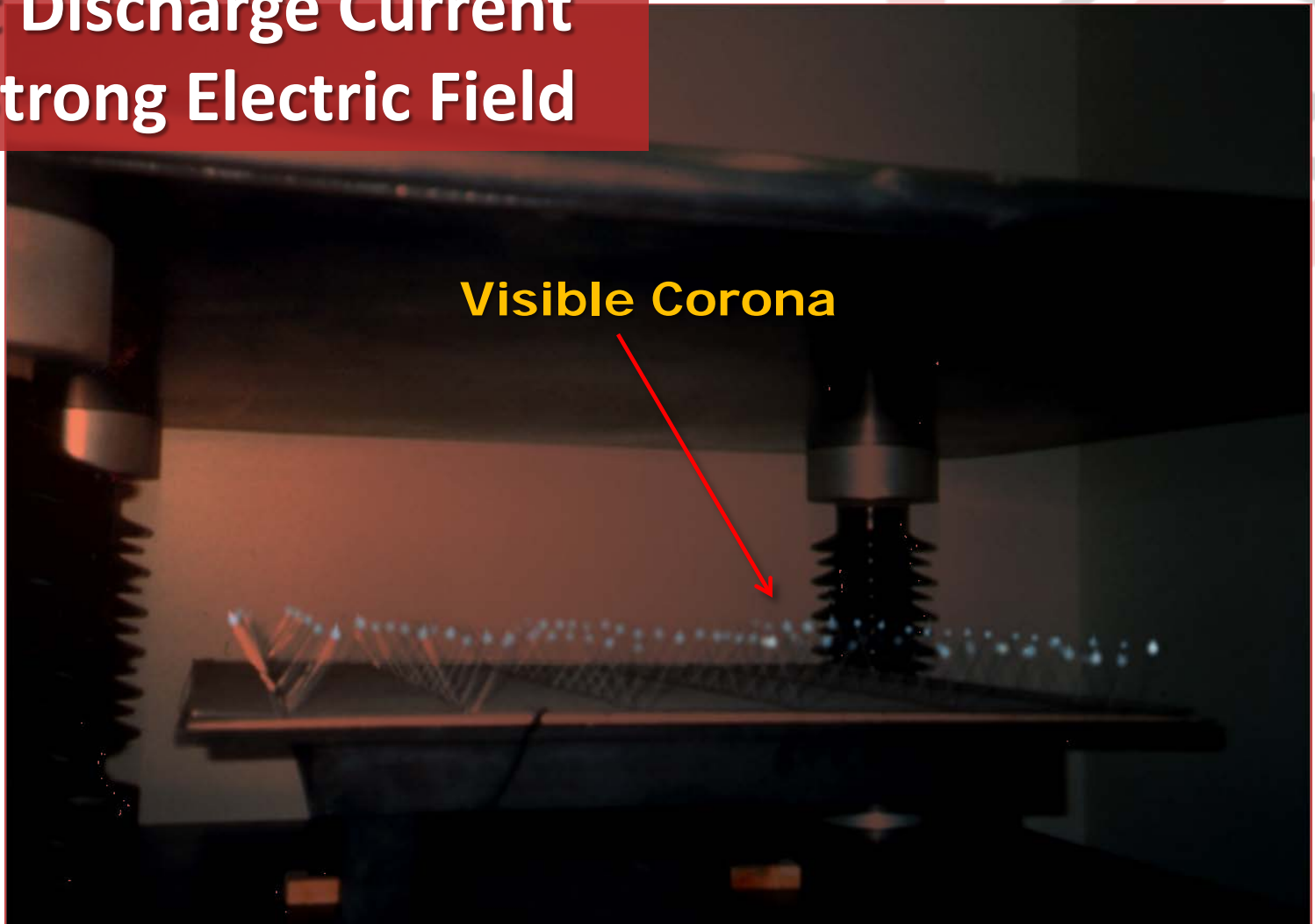
Defines Ionization
Capability

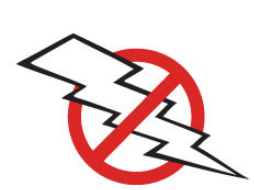




LAB TESTS

Point Discharge Current in a Strong Electric Field



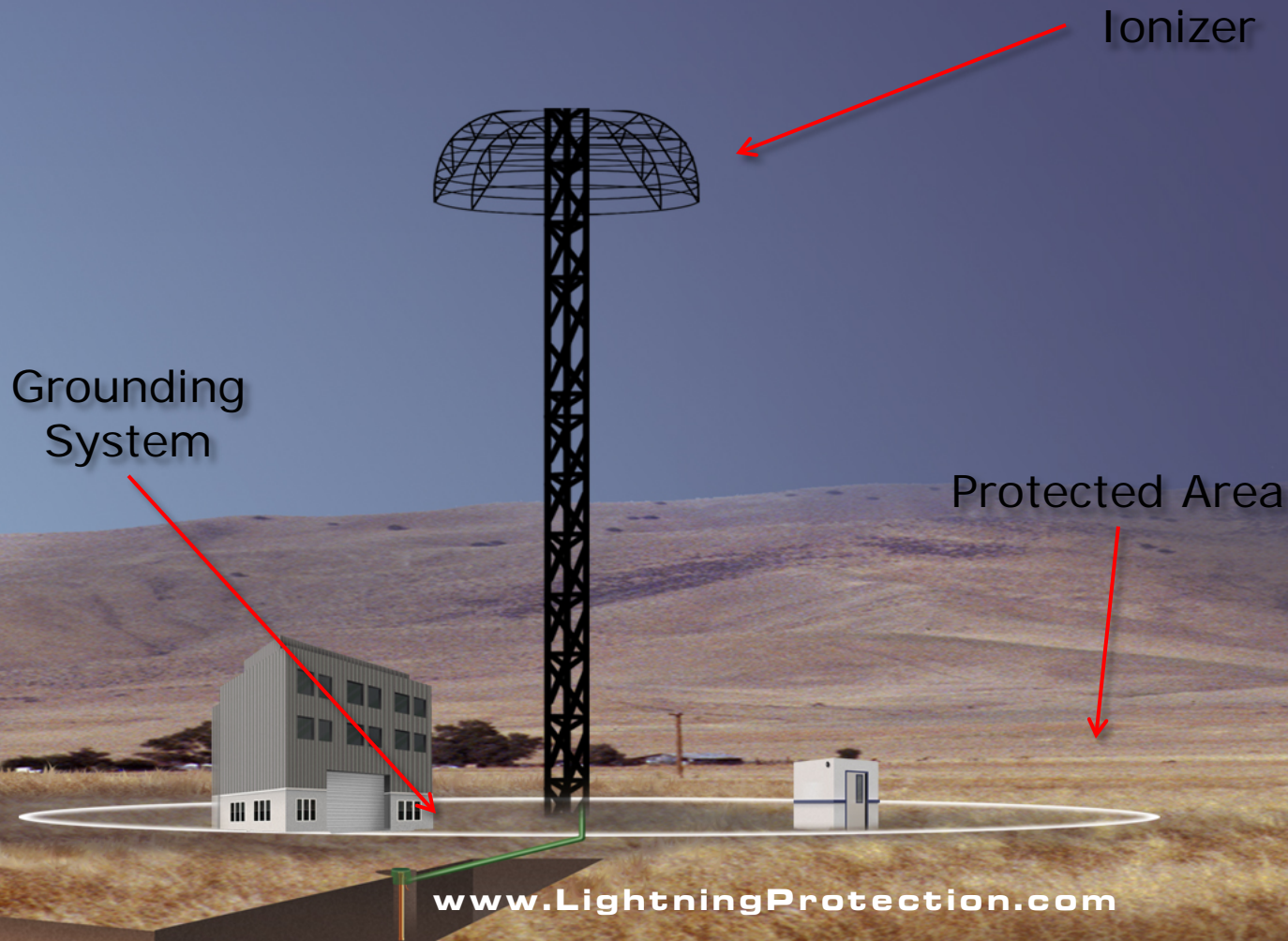


VISIBLE SPACE CHARGE

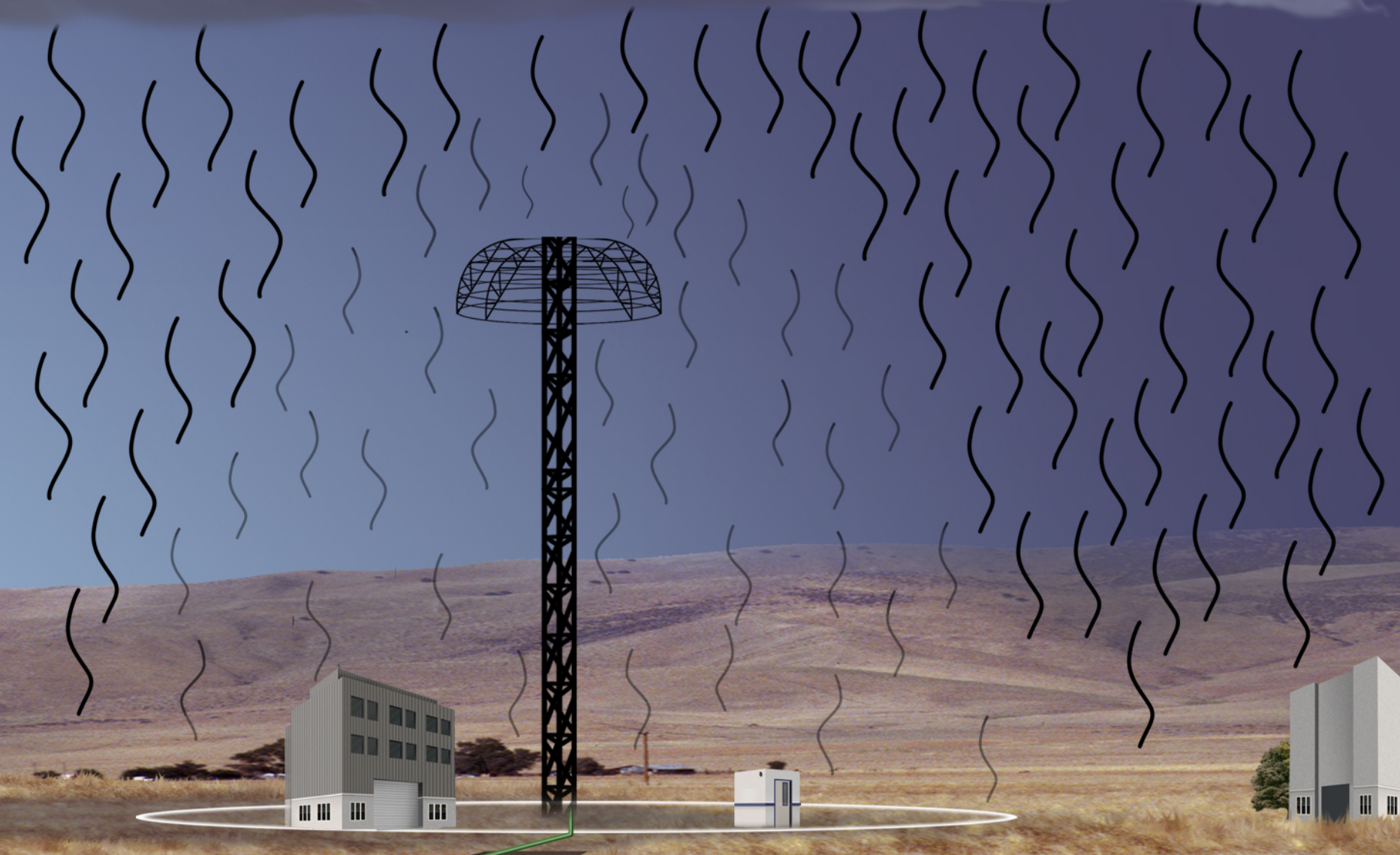
Captured by Exxon Mobil security camera
Mobile Bay, Alabama



Isolating the Site



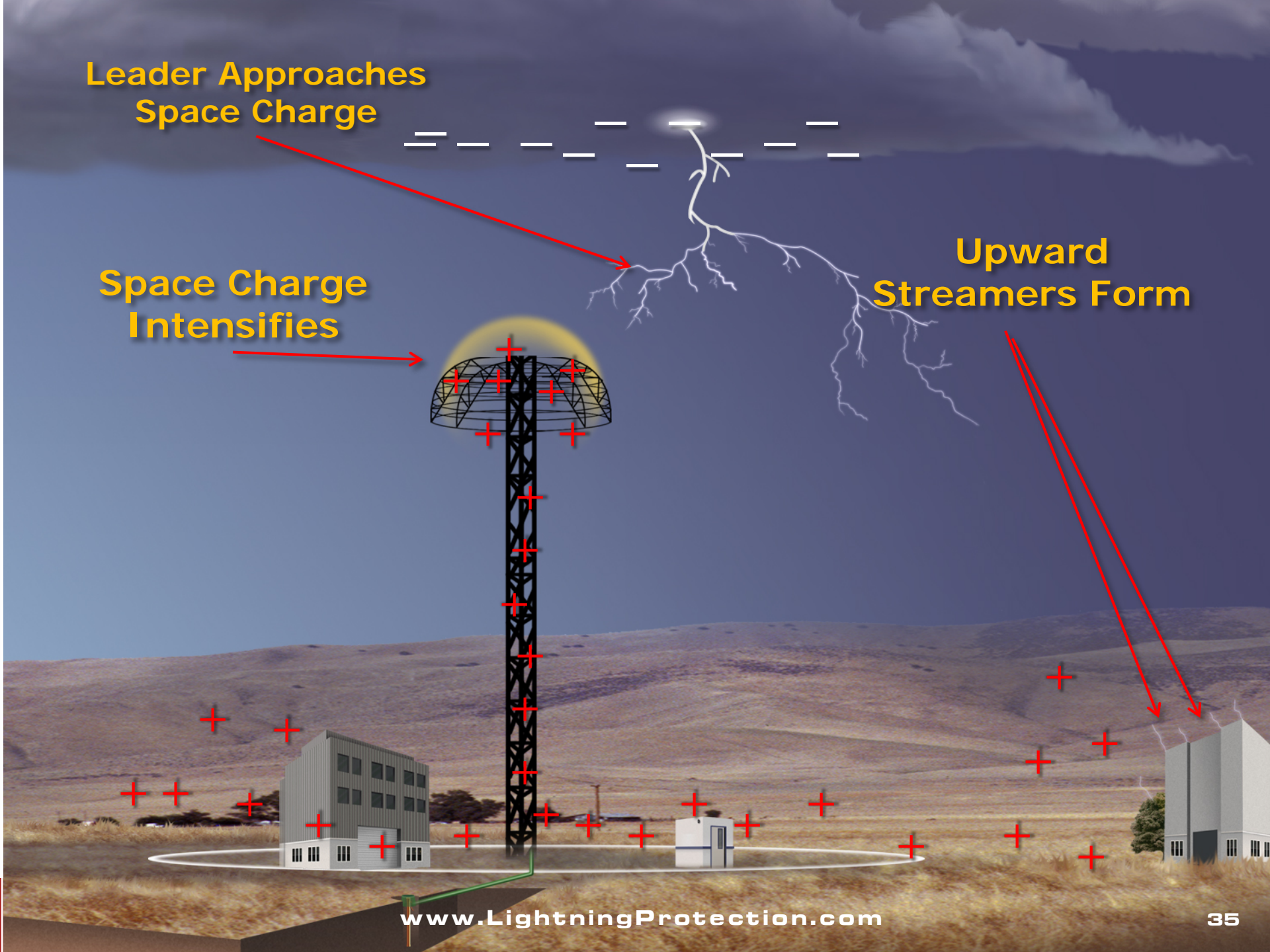
Isolating the Site

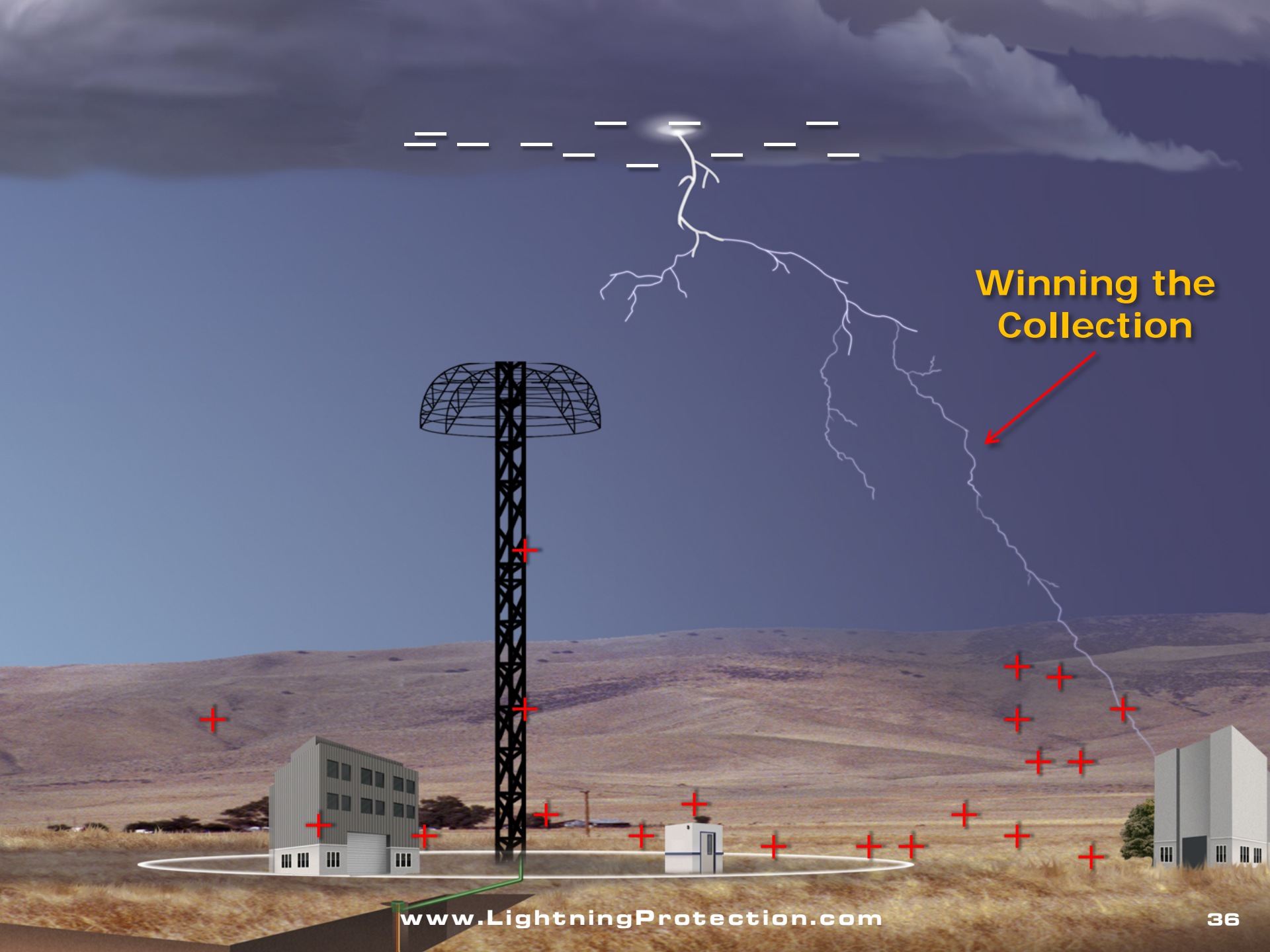


**Leader Approaches
Space Charge**

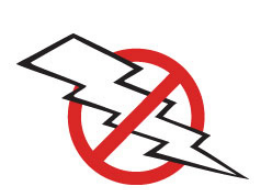
**Space Charge
Intensifies**

**Upward
Streamers Form**





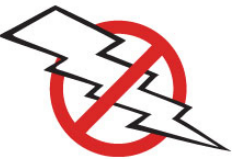
Winning the Collection



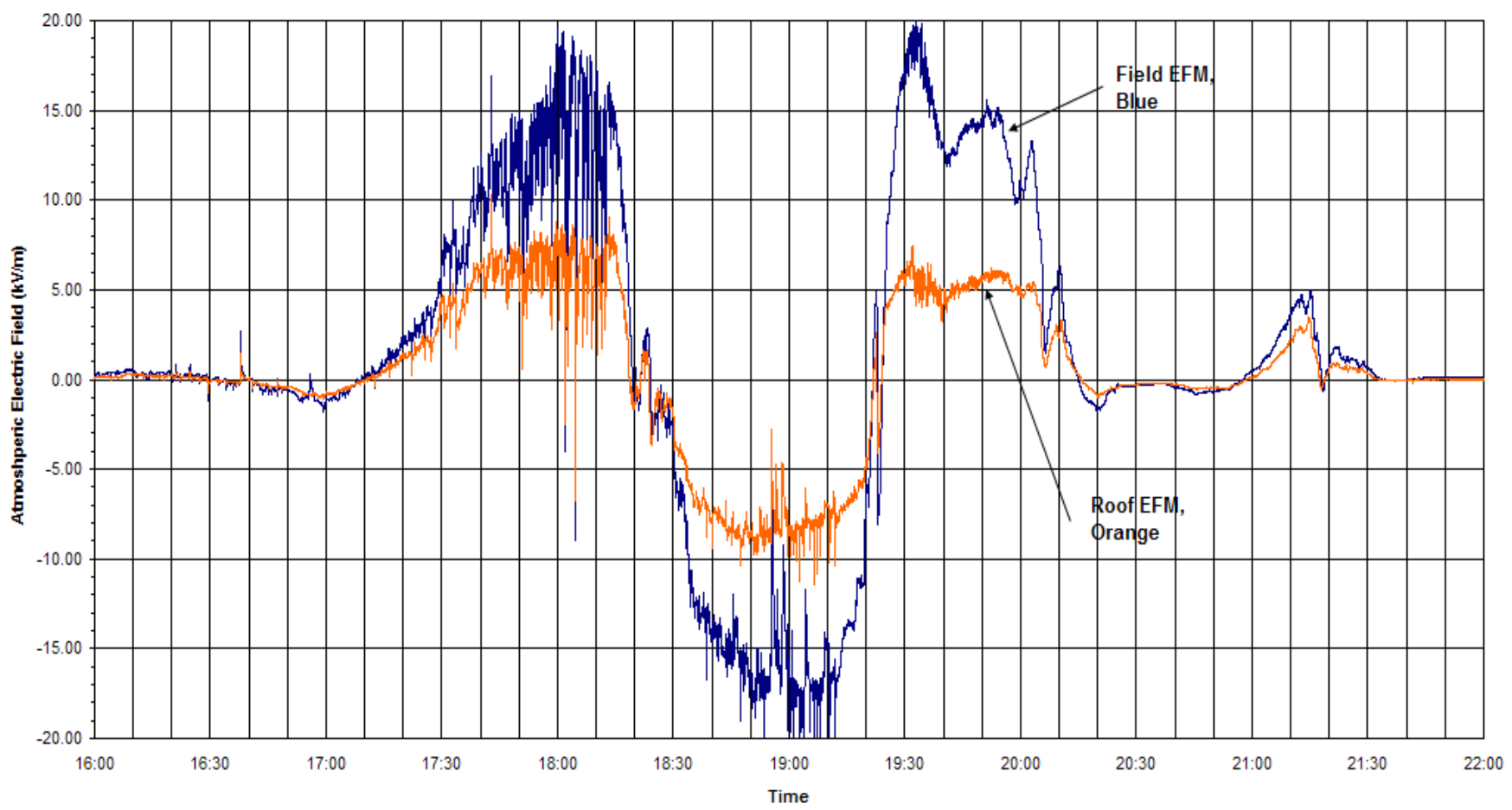
TEST SITE DATA - 2007

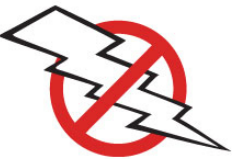
Proving Reduction of the
Atmospheric Electric Field



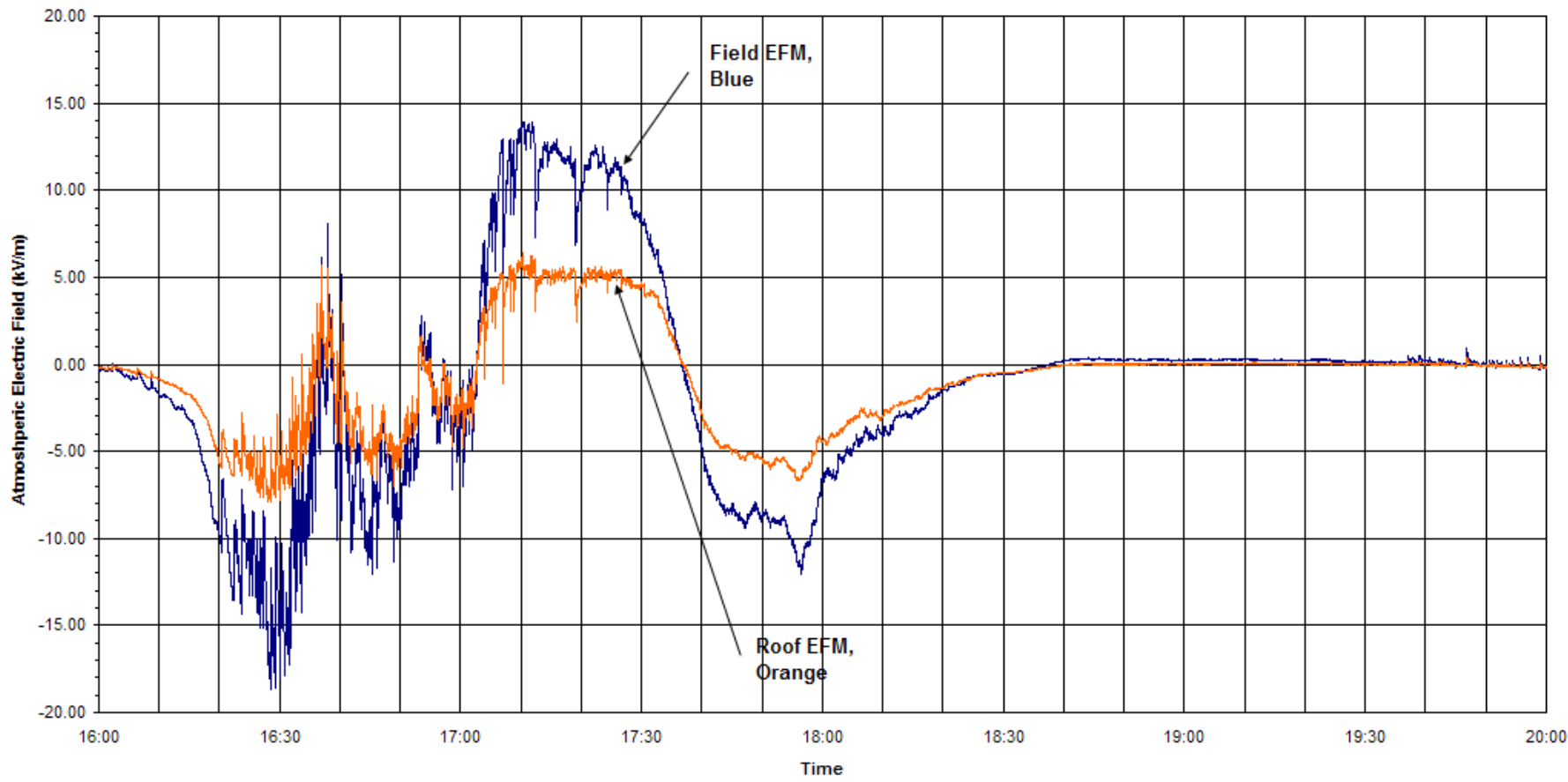


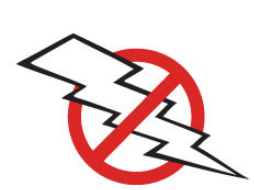
Test Site EFM Comparison (07-07-2007)



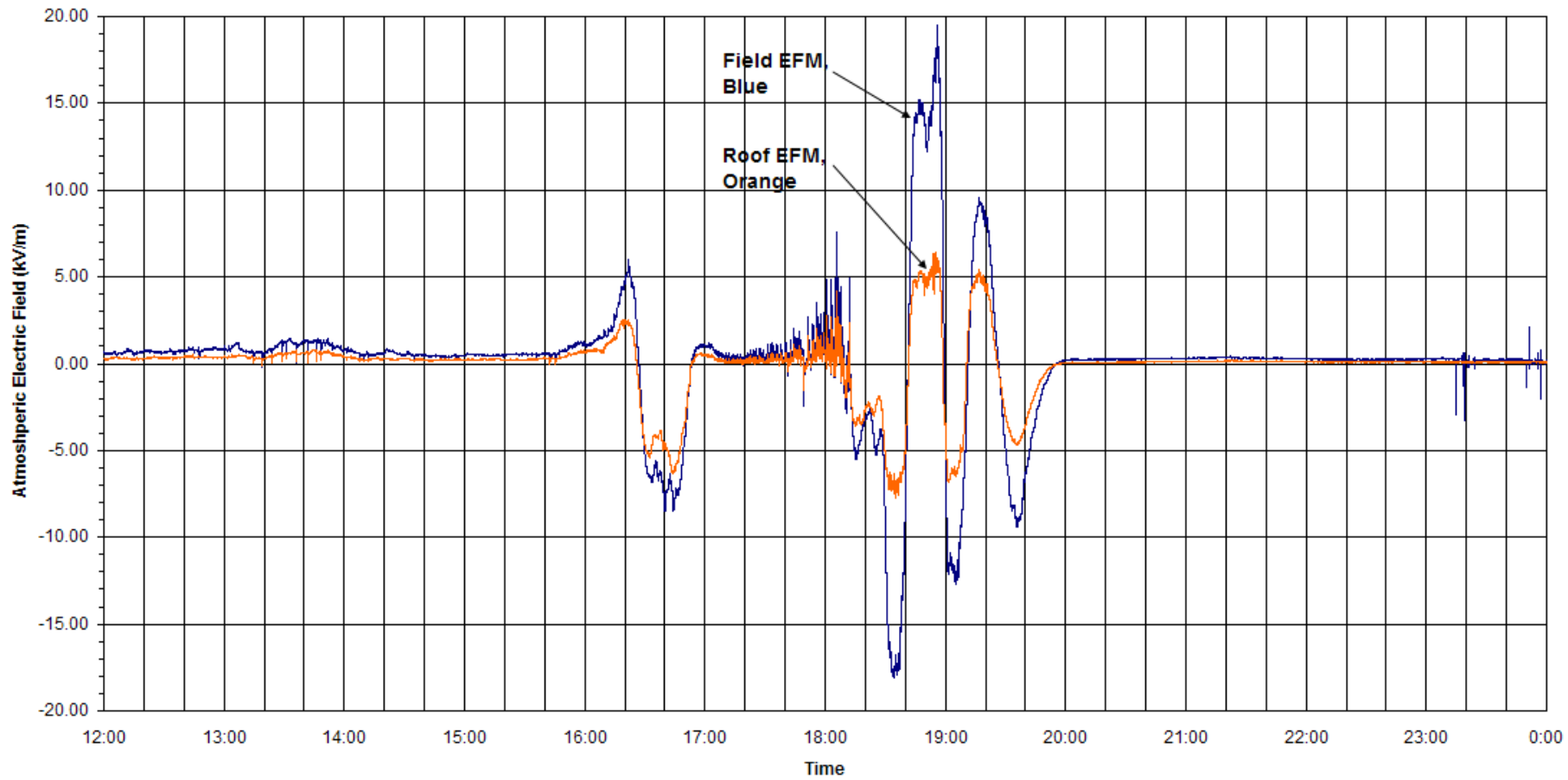


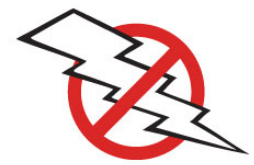
Test Site EFM Comparison (07-25-2007)





Test Site EFM Comparison (08-17-2007)





Test Site Data

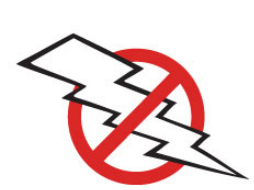
Location: Browns Ferry, Alabama

Location Type: Nuclear Power Plant

Methodology: U.S. National Lightning Detection Network Database (NLDN) & CTS current monitor

Differentiator(s): Charge Transfer technology

- **Dissipation Array System (DAS[®])**
 - **Stack Array > Off-gas stack**
 - **Spline Ball Terminal (SBT[®]) > surrounding area**



Test Overview/TVA Internal Review

Time Line: 6 year Study 1995- 2001

- 3 years before installation of DAS
- 3 years after installation of DAS

Testing Radii:

- 500 meters
- 3 miles
- 6 miles
- 10 Miles

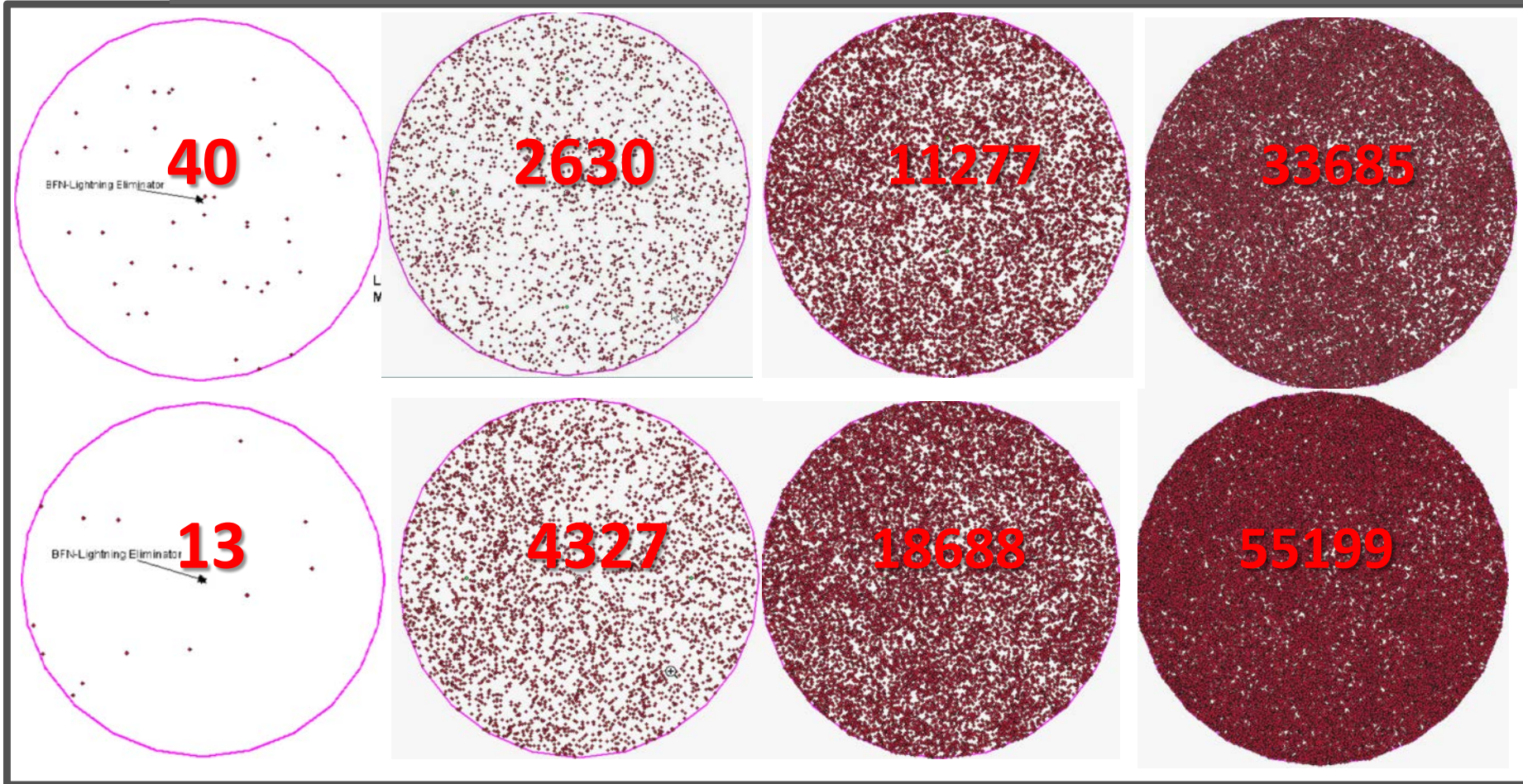
Area of Protection:

- Off-gas Stack (600 Ft. tall/6 ft. Diameter on top)
- Area around base of Off-gas Stack

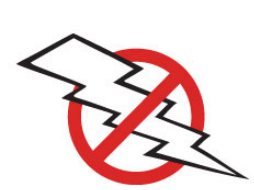
BFN Dissipation Array - NPG Data

Historical strike analysis (Mark Bowman)

Top row is 3 years prior, bottom row is 3 years post installation of DAS



80% reduced within 500m when normalized to strikes in 10 mile circle.



6 Year Review Analysis

Distance From Array	Strikes 3 Years Before Installation	Strikes 3 Years After Installation	Change in Strike Number	Expected Strikes	Actual Normalized
5 00 meters	40	13	0.325	65.54728	0.19833013
3 miles	2630	4327	1.645247148	4327	1.00400642
6 miles	11277	18688	1.657178328	18688	1.01128738
10 miles	33685	55199	1.638681906	55199	1

Petroleum Processing Site



FEDEx SUPER HUB MEMPHIS,

Total Facility = 3 Sq. Km with over 1 billion Sq. Ft. of buildings and space protected



Oil Storage Facility Floating Roof Tanks

Lagoven - Venezuela





Alltel's Corporate Campus

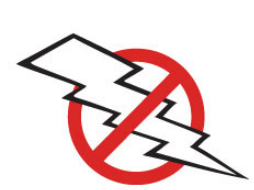
A photograph of an industrial gas processing facility. Two tall, slender distillation columns are the central focus, extending from the bottom to the top of the frame. They are surrounded by other smaller industrial structures and piping. The sky is filled with large, white, fluffy clouds. In the foreground, there are some dark silhouettes of trees and utility poles.

Gas Processing Facility

**Exxon-Mobil,
Mobile Bay, Alabama**

Space Vehicle Tracking Station





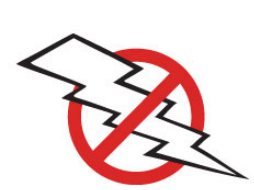
Process Facility

Prevents Ignition Of H₂ Gas

PPG Chemical



USA



TURNER

BROADCASTING, SYSTEM

EARTH STATION FACILITIES

CNN & TBS / Atlanta, GA, USA



Off-Shore Platform



Papua, New Guinea

Paper Processing





The End

DISCUSSION & QUESTIONS

Peter Carpenter
PeterC@lecglobal.com
303-951-3155

www.LightningProtection.com