# Detection and Mitigation of Stray Voltage in Underground Distribution Systems

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# Introduction

- Aaron Prazan, Engineer

  ConEdison Distribution Engineering – focused on analysis of testing and inspection programs as part of a stray voltage mitigation strategy

- David Kalokitis, CTO

  Power Survey Company – a technology and service provider focused on detection and mitigation of Stray Voltage

# Presentation Overview

- Stray Voltage Concerns
- Locating Stray Voltage
- Mobile SV Detection Equipment & Methods
- Troubleshooting Approach
- Traditional Manual Testing
- Mitigation Strategy
- Mitigation Program Findings
- Case Studies
- Challenges Going Forward
- Conclusion

# Mission Statement

**"Protect the public and improve public safety through the mitigation and elimination of stray voltage"**

# Definitions

**Stray Voltage:**

**Focused on Contact Voltage**

- **Publicly Accessible**
- **System anomaly, not design issue**
- **Not traditional 'Stray Voltage'**

**Occurring on Underground Distribution**

- **Network or Radial**
- **Underground Residential**
- **Backyard Construction**

# Stray Voltage Concerns

- Public Safety
  - Hazard to general public (human and animal)
- Regulatory Compliance
  - Increasing trend to mandate testing
- Operational Efficiency
  - Accomplish safety goals
  - Continuous, scalable activity
  - Detect all hazards, eliminate nuisance detections

# Locating Stray Voltage

- Nature of the System
- Mobile Detection
- Manual Screening Tests

Procedure and Process Dictate Results

# Mobile Detection Approach

- Energized structures and surfaces are sources of Electric Field (E-field)
- A sensitive E-Field detector can move systematically through a territory
- When the E-field detector alarms, a technician pinpoints the source of E-field
- The technician carefully investigates the source and measures voltage
- Document survey coverage and findings

# SVD2000 System

# Operation and Features

- Targeted at underground distribution area
- Secondary overhead distribution and temporary shunts do not preclude effective detection
- Operates at speeds up to 20 MPH
- Sophisticated signal processing allows only 60Hz
- Enabling technology for detection operations

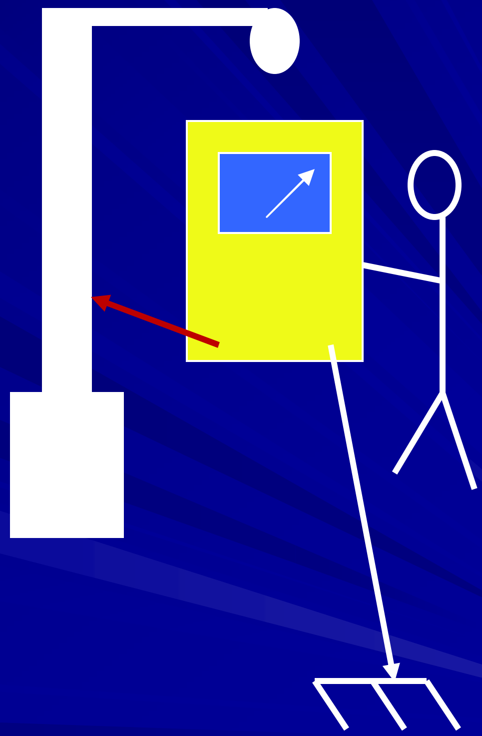
# Operation: Live Display

# Mobile Stand Off Detection

- Alarm from SVD2000 points to a source of E-field
- Technician will pinpoint source
- The technician carefully investigates the source, knowing it is likely energized
- Use troubleshooting techniques instead of screening techniques

# Troubleshooting Methods

- Strong E-field emanating from street lamp
- It's likely energized, let's measure the potential
- Use a voltmeter, make contact to the pole and find a good ground
- Be sure the selected ground is at low potential, check for E-field
- Measure with and without 500 Ω shunt (load resistor)
- Working group should address resistance value



# It works because:

- Technician knows there is a source of potential and he will:
  - Pinpoint the source
  - Find and qualify a ground reference point
  - Measure carefully with voltmeter
- Source can be any object or surface
  - No asset list dependence
  - Non-traditional hazards are discovered
- Fast and Efficient
  - Faster cycle time suitable for multiple scans per year

# Traditional Manual Testing

- Typically, a worker will
  - Screen assets
  - Use a contact measurement method
  - Look for a step potential
- The worker will “find” energized structures Only IF
  - The structure is on the asset list
  - Good contact is made to structure
  - Ground reference point is not energized

# Manual Testing with Contact Probe Pros & Cons

## Pros

- **Cheap and easy to implement**
- **Many devices on the market**
- **Successfully detected ~5,000 energized items in 3 yrs in NYC**

## Cons

- **Limited to asset list items only**
- **Can't verify negative reading**
- **Voltmeter with shunt req'd to prevent false positives**
- **If surrounding area is energized, probe may not light**

# Mitigation Strategy: Test, Inspect, Upgrade

- Reduce exposure now
  - Multiple system tests
    - Testing >700,000 utility facilities manually
    - >100,000 site visits by employees during regular work
    - Mobile testing of underground system 4+ times per year
  - Corporate culture change/awareness
- Reduce emergence in future
  - Inspect & Repair
  - Capital improvement
  - R&D

# Mitigation Program Results

- Findings from the field
- Non-traditional hazards
- Third party involvement
- Working field procedures

# Mitigation Program Findings

Voltage detected on many surfaces

- Testing structure covers not effective

Third party involvement is common

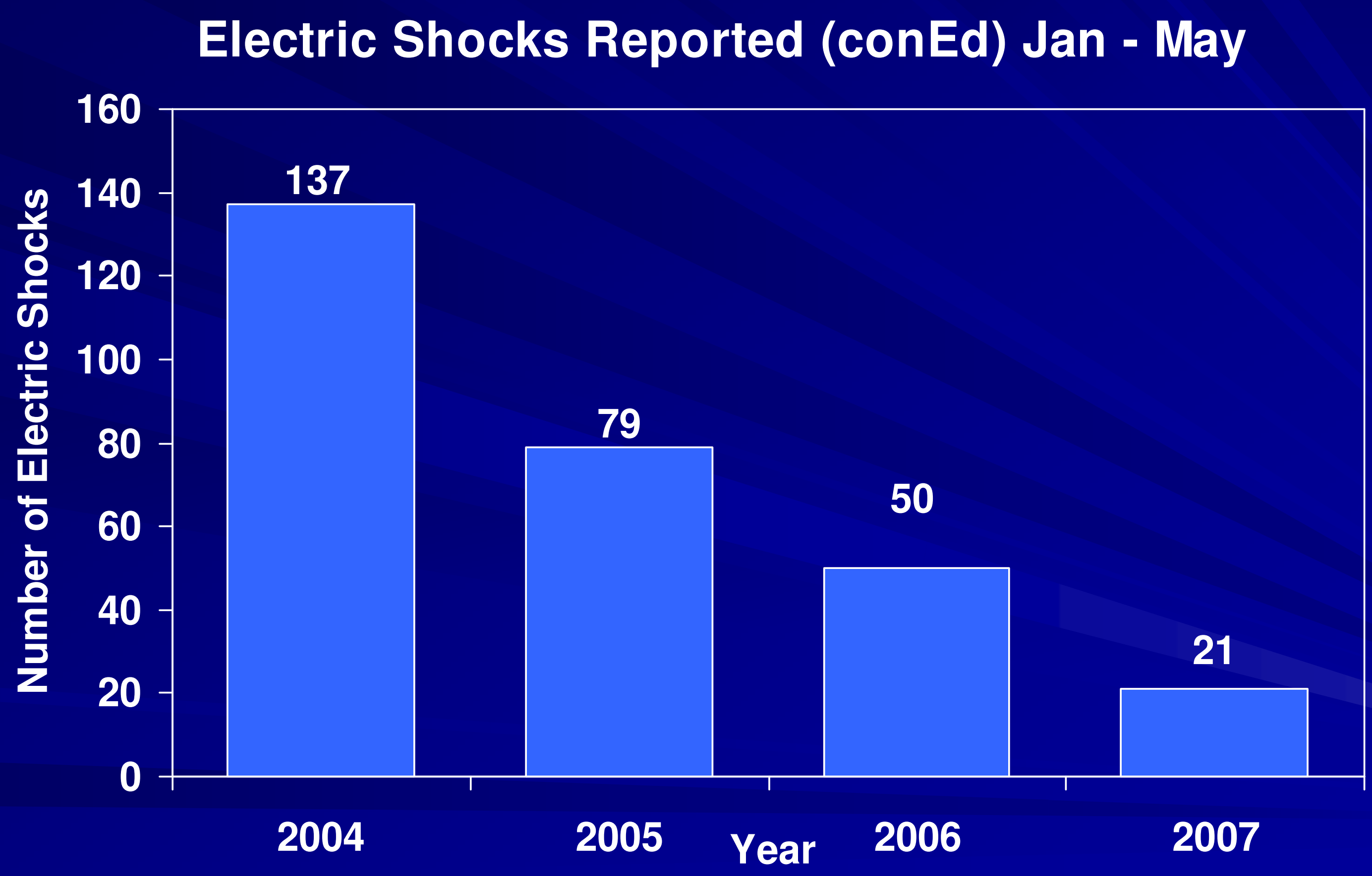
- Notification and follow up are crucial

Large volume of repairs

- Program affects whole organization

| | Total | Con Ed | 3rd Party |
|---|---|---|---|
| S/L | 2060 | 824 | 1236 |
| T/L | 957 | 35 | 922 |
| Sidewalk | 283 | 261 | 22 |
| CE Cover | 260 | 254 | 6 |
| Traffic Sign | 179 | 9 | 170 |
| Gate | 94 | 55 | 39 |
| Scaffolding | 68 | 8 | 60 |
| Customer Equip | 49 | 8 | 41 |
| Bus Shelter | 38 | 1 | 37 |
| Traffic Control Box | 26 | 0 | 26 |
| Phone Booth | 19 | 5 | 14 |
| Non-CE Cover | 19 | 8 | 11 |
| Fire Hydrant | 17 | 12 | 5 |
| Pole | 8 | 4 | 4 |
| Riser | 4 | 3 | 1 |
| Water Pipe | 2 | 2 | 0 |
| Trench | 1 | 1 | 0 |
| Other | 1 | 1 | 0 |
| Total | 4085 | 1491 | 2594 |

# Strategy Pays Off Through Reduced Shocks



# Stray Voltage Not Confined to Manholes Only

Only 6% of SV found on structure covers

Asset testing and monitoring doesn't accomplish safety goals

33V found on Brooklyn mailbox caused by burned service leg underground.

108V found on streetlight on beach. Repaired corroded neutral.

60V found on Foster Av sidewalk & front lawn. Service replaced.

# Case Study:  St. Catherine's Church


**Feb 28, 2007**

**112V on fence**

**Service duct cracked by tree roots under sidewalk**

**Detected by mobile detector and repaired**

# Operational Challenges

Third party involvement

- Communicate with owners and responsible agencies
- Follow up to maintain public safety, credible relationships with third parties

Impact to whole organization

- Increased repair volume
- Awareness at all levels
- Need for clear operating procedures

# Technical Challenges

- Handheld tools
  - Contact probes – successfully detects energized objects
  - Field detectors – allows positive verification of negative reading, verification of grounds
- Shunt resistor – is 500Ω the right value?
- Choosing good foreign grounds
- Choose threshold based on hazardous condition

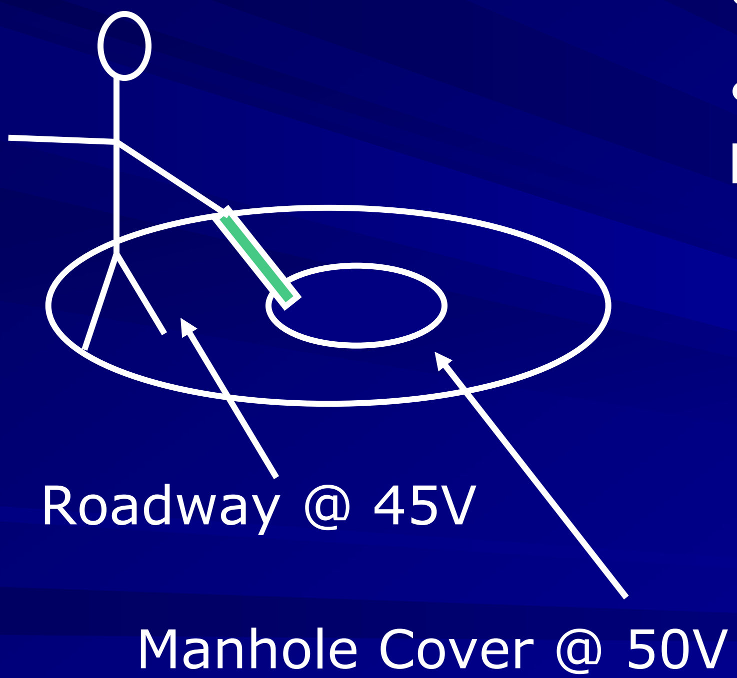
# Conclusion

- Goals
  - Public Safety
  - Regulatory Compliance
  - Operational Efficiency
- Challenges
  - Many surfaces may be energized
  - Third parties and operations burden
- Solution
  - Stand-off detection method
  - Rational testing protocols based on hazardous conditions

# Questions

?

# Possible Results

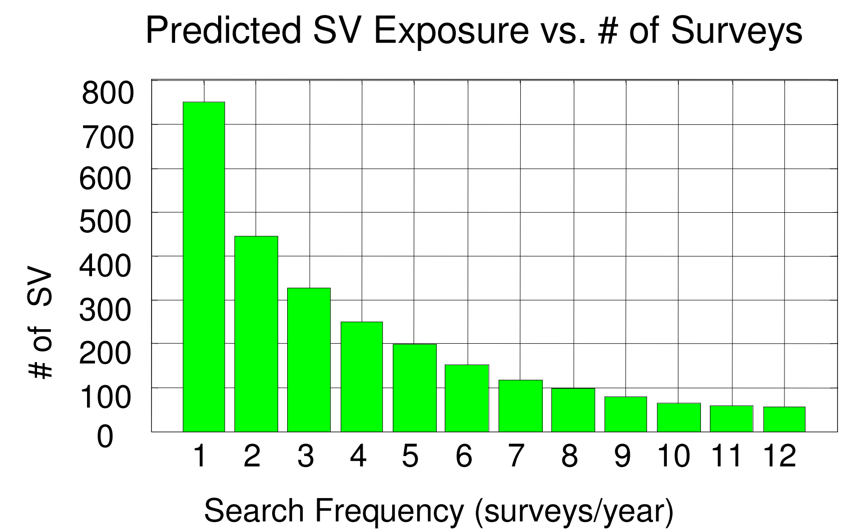


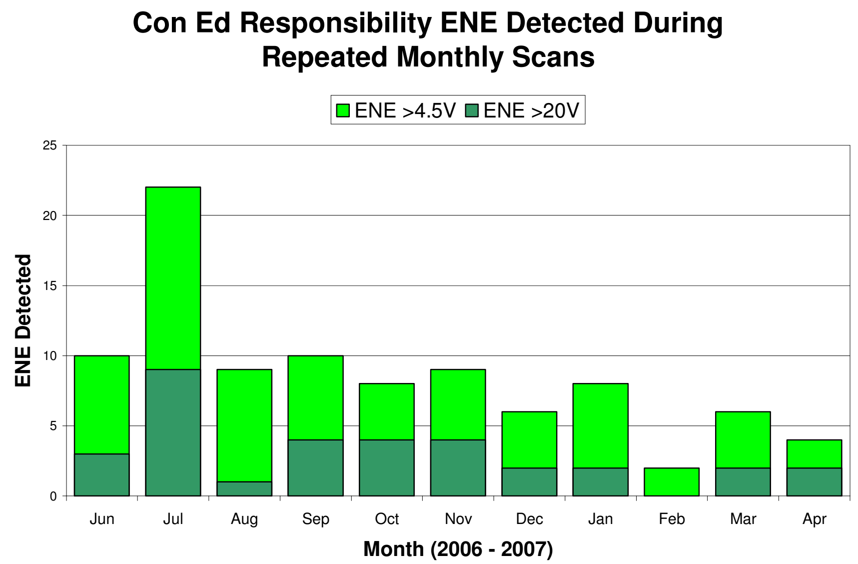

- Object was a recognized asset (manhole cover)
- Probe made good contact to cover
- Ground reference at high potential

Result:

Inspector may miss voltage

# Reduced Stray Voltage Exposure Thru Multiple Scans



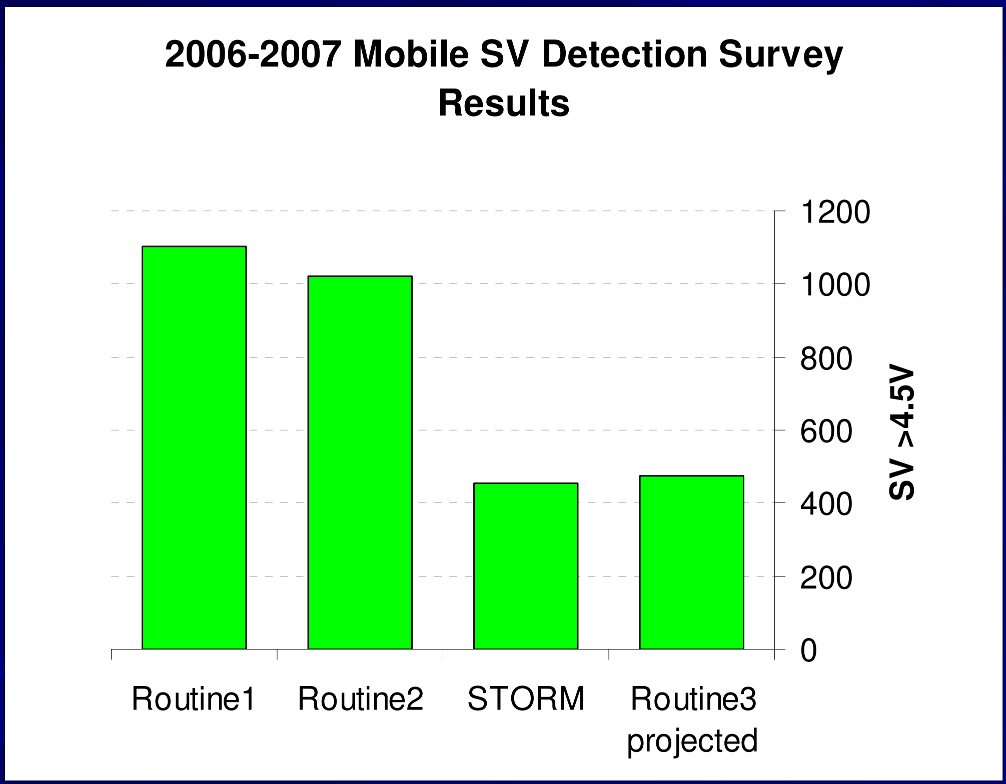

Assumptions

- New SV created over time
- Less than 100% detection each time

Expected result

- Fewer SV found with each scan
- Fewer SV on system at all times
- Major reduction in shocks

# Reduced Stray Voltage Exposure Thru Multiple Scans (cont'd)




Finding less SV during successive scans

- Catching up with emergence rate
- Real measure of success is reduced shocks

# Root Causes

## Streetlights

- Duct corrosion or collapse
- Neutral corrosion
- Light damage/removal
- Connections accessible to the public

## Structures & Sidewalks

- Chemical damage from salt
- Duct edge/rack arm dig in
- Grounding problems
- Flooding and pump failure

# Reduction in Severity

Observed voltage levels reduced over time

| Average Voltage Measured For all SV Detected/Reported | | |
|---|---|---|
| | Detected SV Voltage | Shock Report Voltage |
| 2004 | 32 | 42 |
| 2005 | 23 | 42 |
| 2006 | 23 | 48 |
| 2007 (to date) | 19 | 22 |

# SV Emergence Rate

Data gathered from special test areas allows estimate of ‘emergence’ of new SV on the system.

- 3200 ENE predicted per year, system-wide

Actual findings have been consistent with these projections

~2900 detected >4.5V to date

~3000 projected by completion of survey #3 in summer 2007

# Results of 2006 Mobile Testing Program

- 4085 total SV detected in 1 year
  - 260 covers
  - 3222 streetlights/traffic lights
- Over 18,000 miles covered
- Mobile testing goes where other testing programs do not reach

| Stray Voltage Sources Not Testable in Manual Programs | |
|---|---|
| Sidewalk | 283 |
| Gate | 94 |
| Scaffolding | 68 |
| Customer Equip | 50 |
| Bus Shelter | 38 |
| Phone Booth | 19 |
| Non-CE Cover | 19 |
| Fire Hydrant | 17 |
| Other | 3 |
| Water Pipe | 2 |
| Trench | 1 |
| Total | 599 |