

# Seismic Mitigation of Existing Substations

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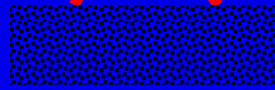
# Seismic Mitigation of Existing Facilities

Cost Effective Solutions

Investment  
Protection

Power System  
Recovery

Transformer  
Anchorage and Hardening



Critical  
Path Through  
Substation

# VULNERABILITY

## PROBLEMS: SCALE OF 1 TO 7

1

Lack of Anchorage  
Porcelain Components  
Ground Settlement

Most Vulnerable

■ Anchorage Failure

■ Sway or Rocking Motion

■ Dislodged Electrical Components

■ Electrical Burnout

■ Vibration W/Impact

■ Miscellaneous

■ Gravity Missiles

■ Isolation Mount

7

Differential Displacement of Footings

Vibration Damage

Water Spray

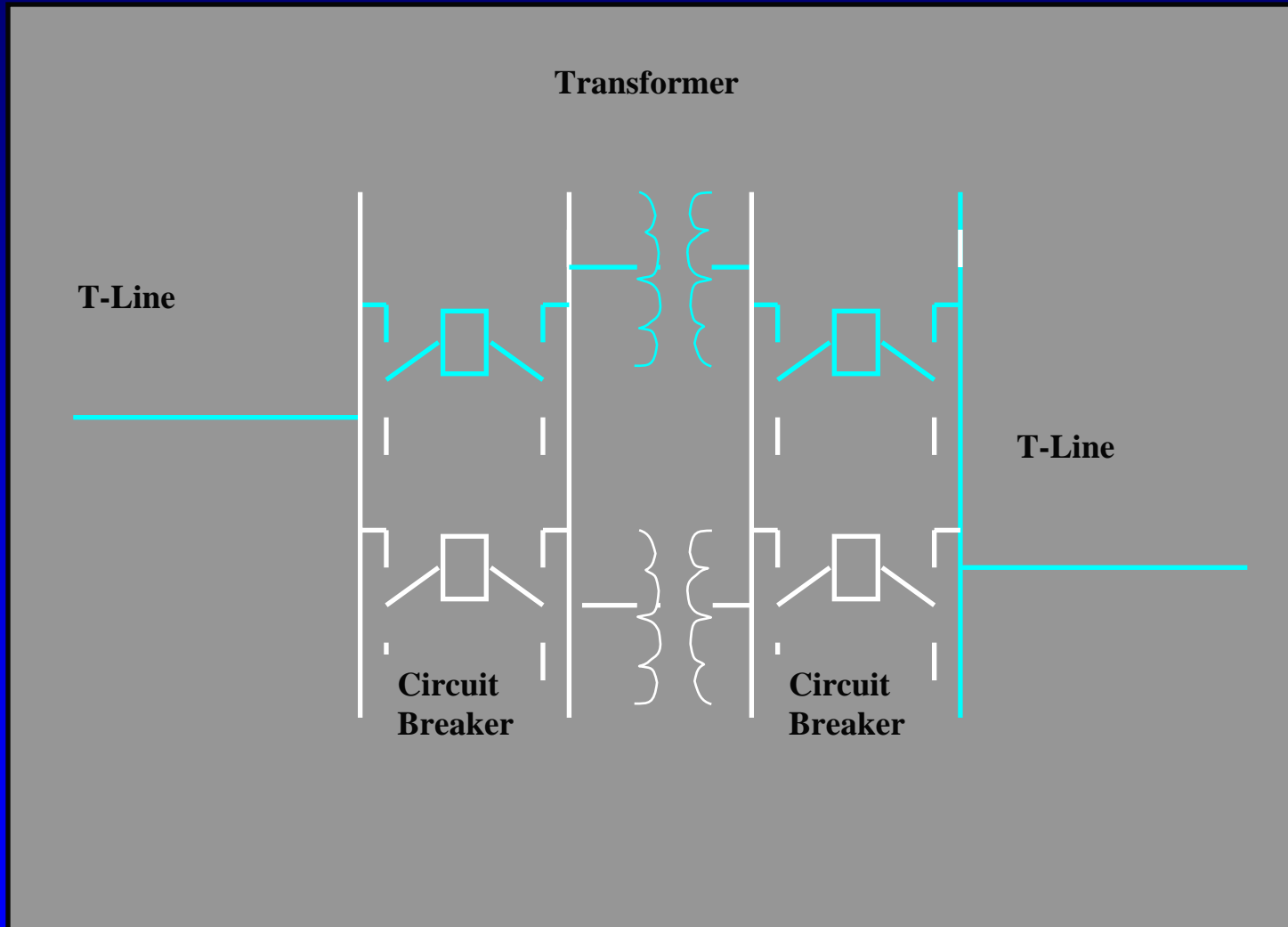
Defective Equipment

# FRAGILITIES

## Damage Thresholds (for illustration only)

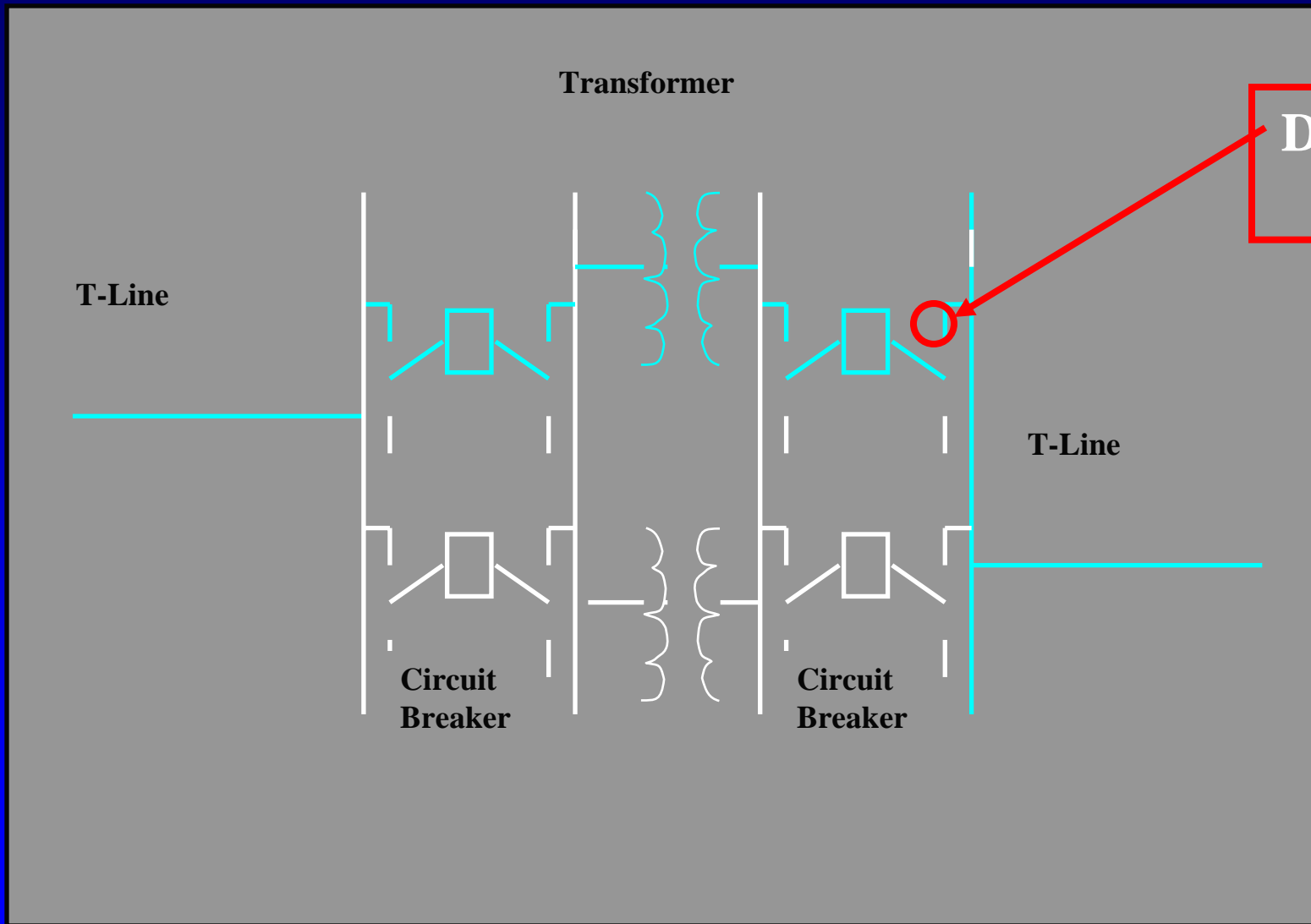
EQUIPMENT TYPE	500KV	230KV	115KV
Live Tank Circuit Breakers	0.05g	0.10g	0.20 - 0.30g
Current Transformers	0.10g	0.20 - 0.35g	0.50g
Lightning Arresters	0.10g	0.20 - 0.35g	0.75g
Disconnect Switches	0.10g	0.20g	0.60g
CCVTs	0.10g	0.20 - 0.35g	0.75g
Transformers - Unanchored	0.15g	0.15g	0.15g
Rigid Bus Structures	0.20g	0.20 - 0.35g	0.75g
Wave Traps - Cantilever	0.30g	0.25 - 0.40g	0.75g
Dead Tank Circuit Breakers	0.40g	0.50g	> 0.70g

# Power System Recovery



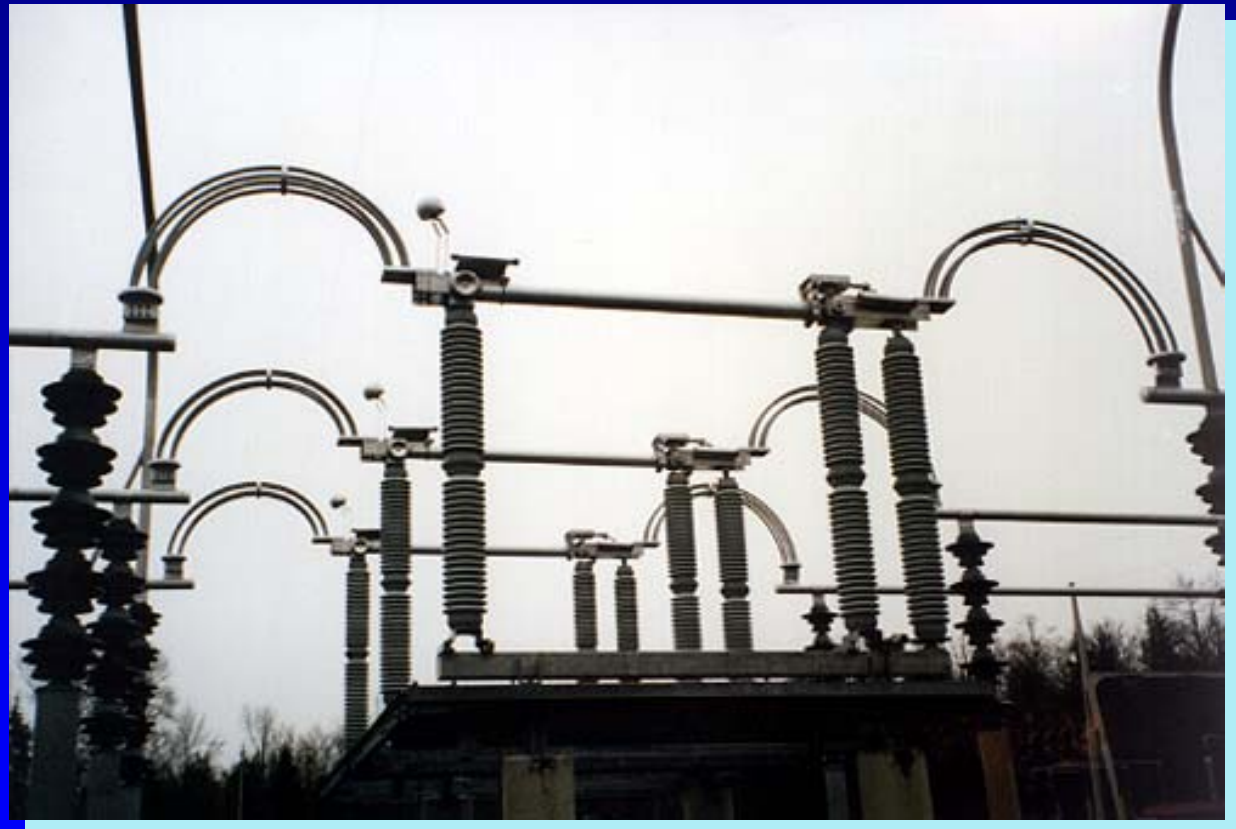
## Critical Path Approach

# Power System Recovery

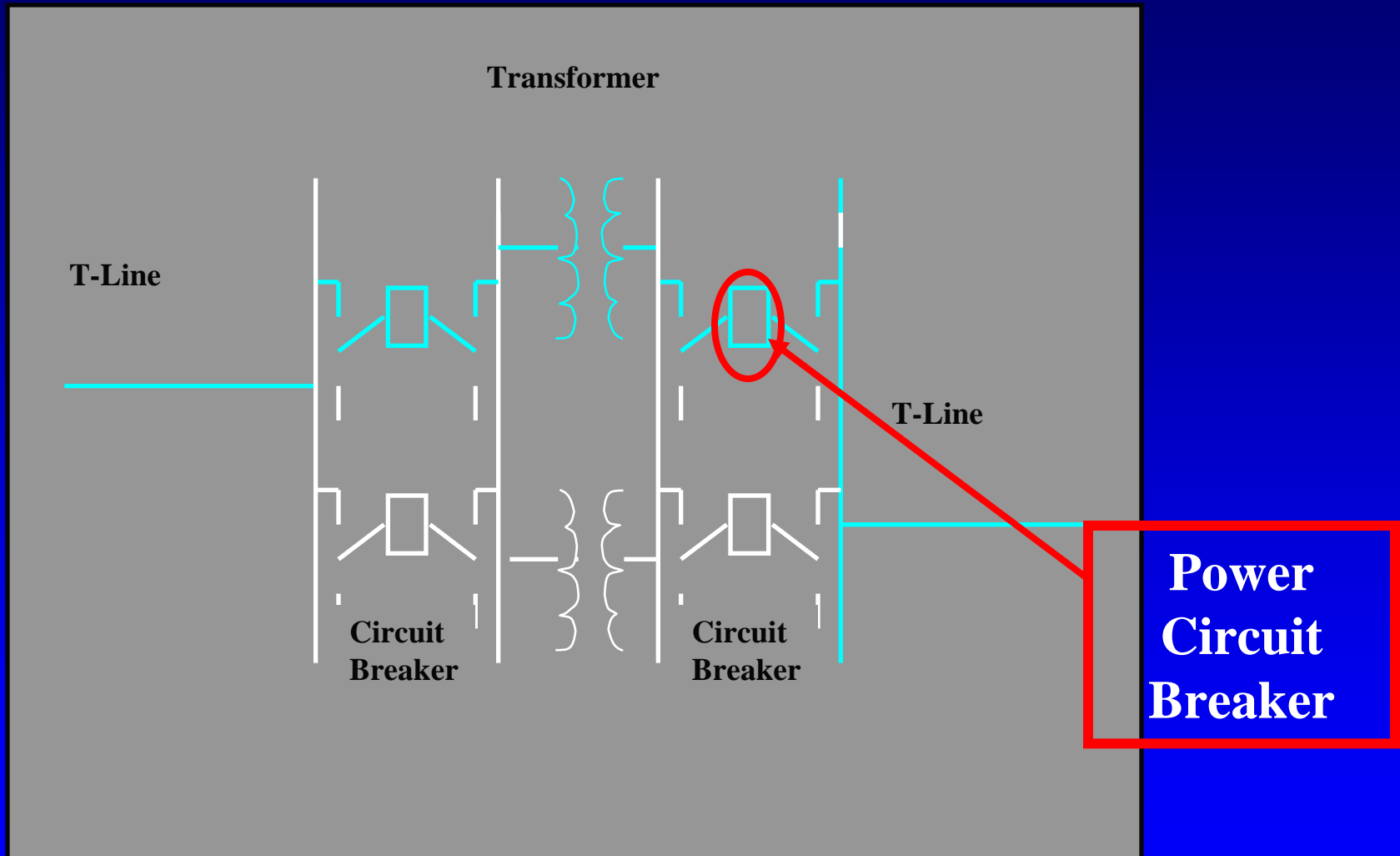


## Critical Path Approach

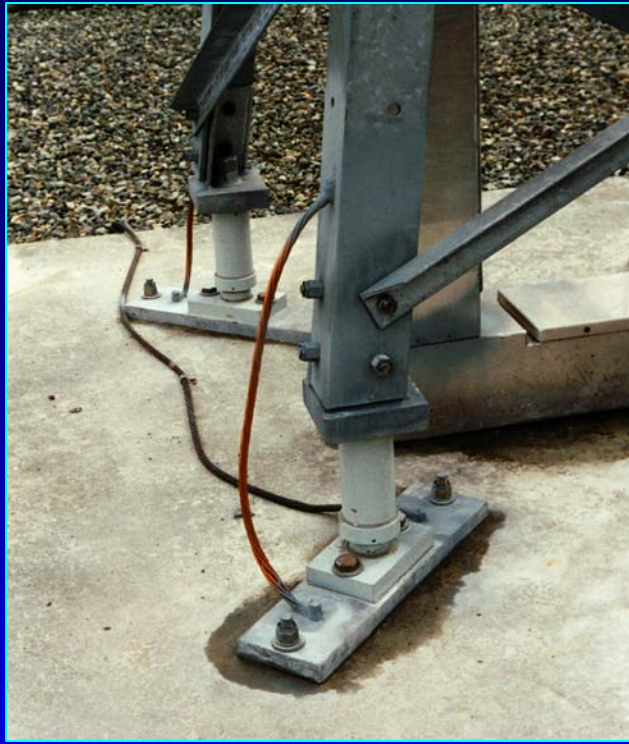
# Disconnect Switch



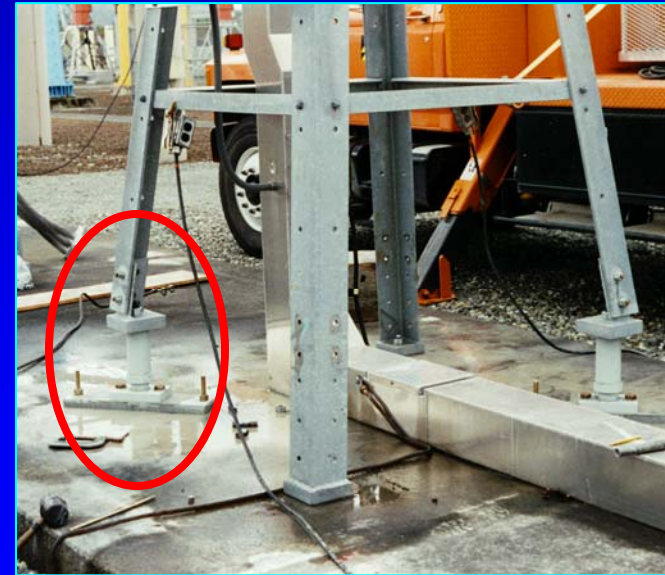
# Power System Recovery



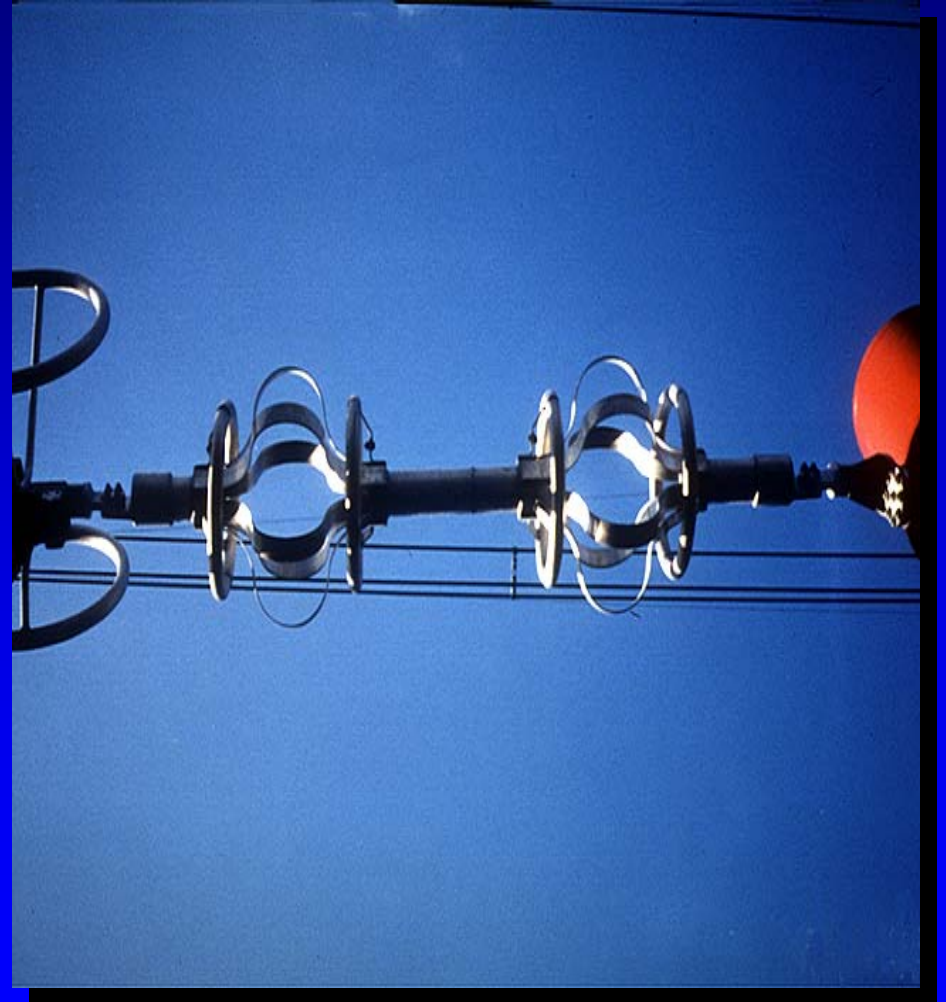
## Critical Path Approach



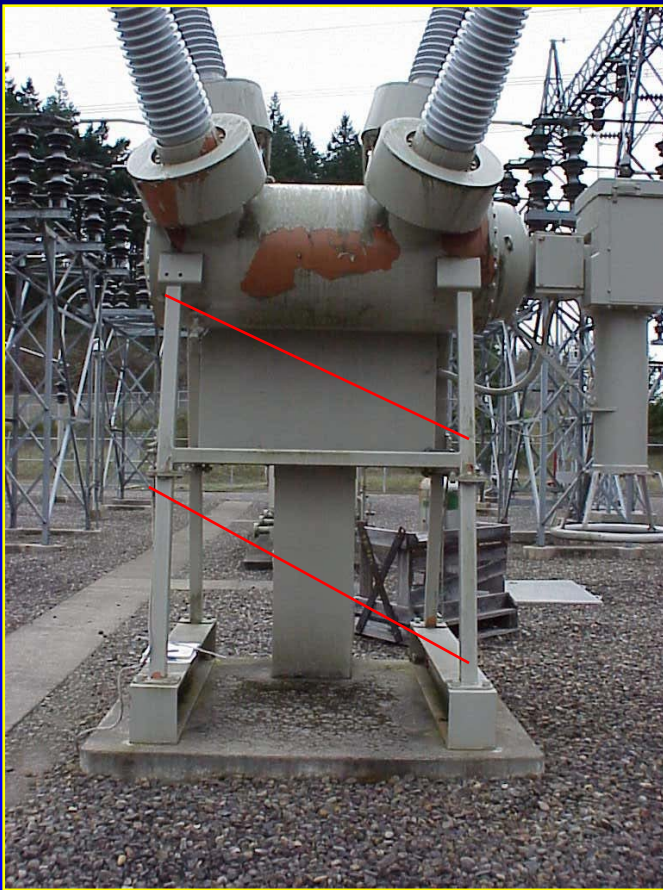
## 500kV Power Circuit Breaker Mitigation



# Flexible Connections



# Power Circuit Breaker - Bracing and Anchoring



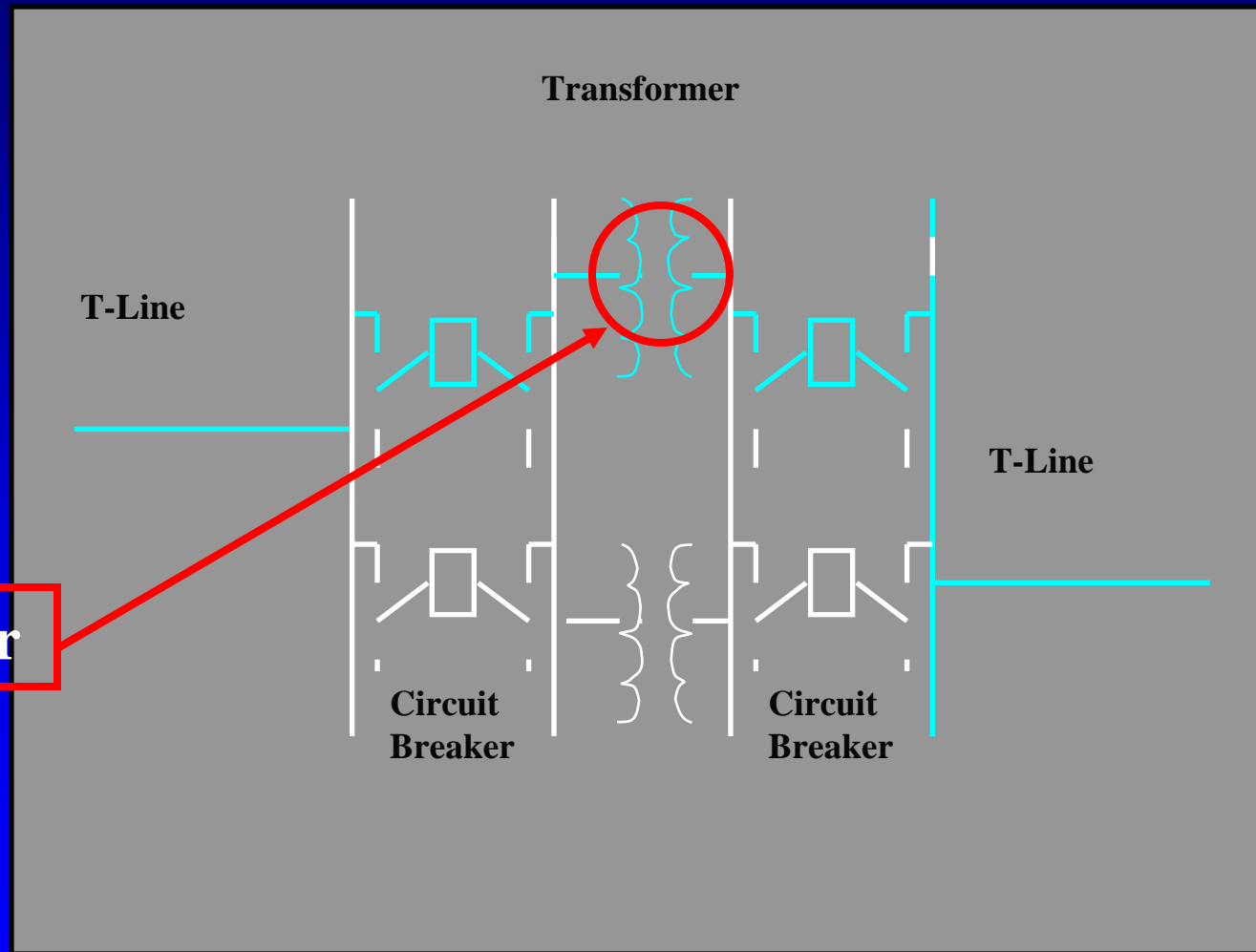
**Gas Circuit Breaker**



**Bulk Oil Circuit Breaker**

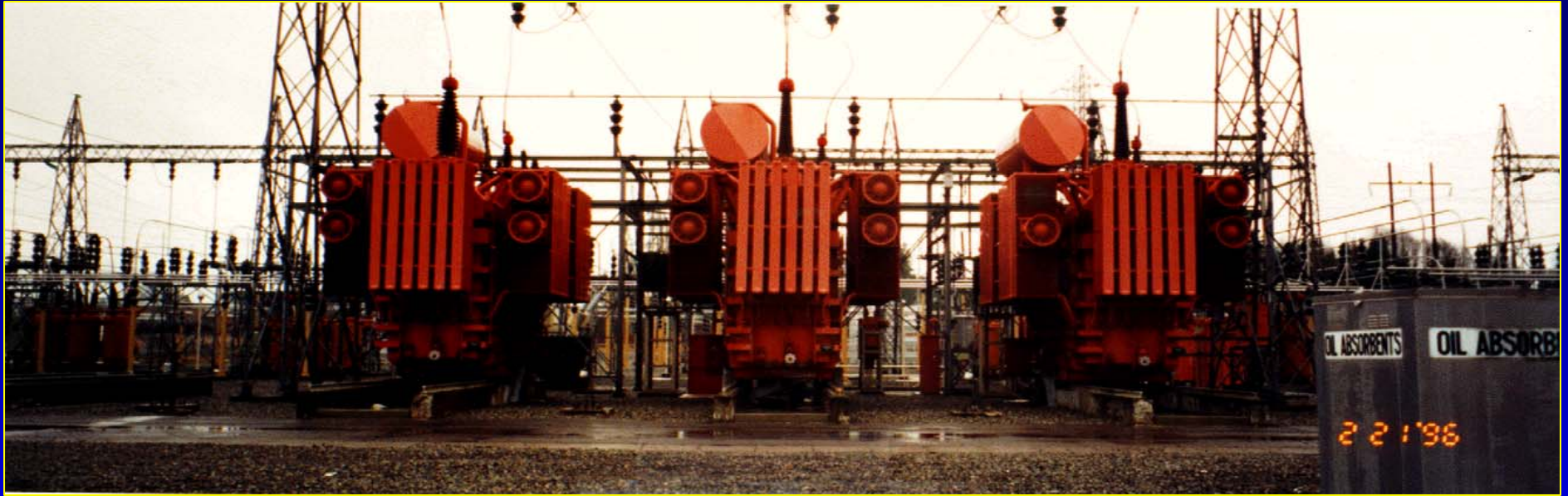


# Power System Recovery

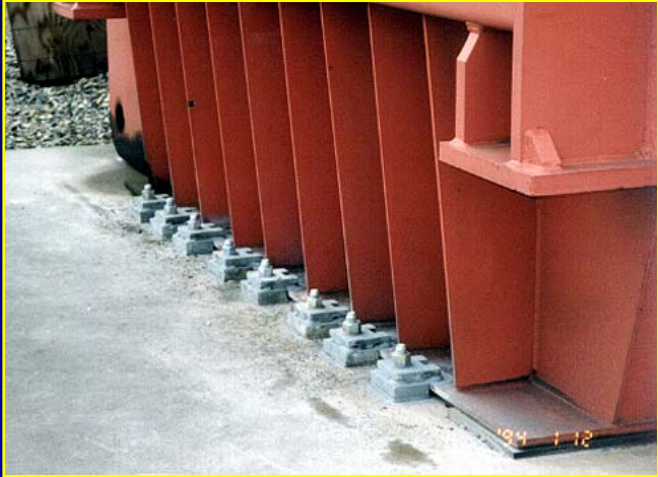


**Critical Path Approach**

# Transformer Anchorage - Investment Protection



# Pad Mounted



# Transformer Connection Flexibility and Bracing



## Station Service Transformers

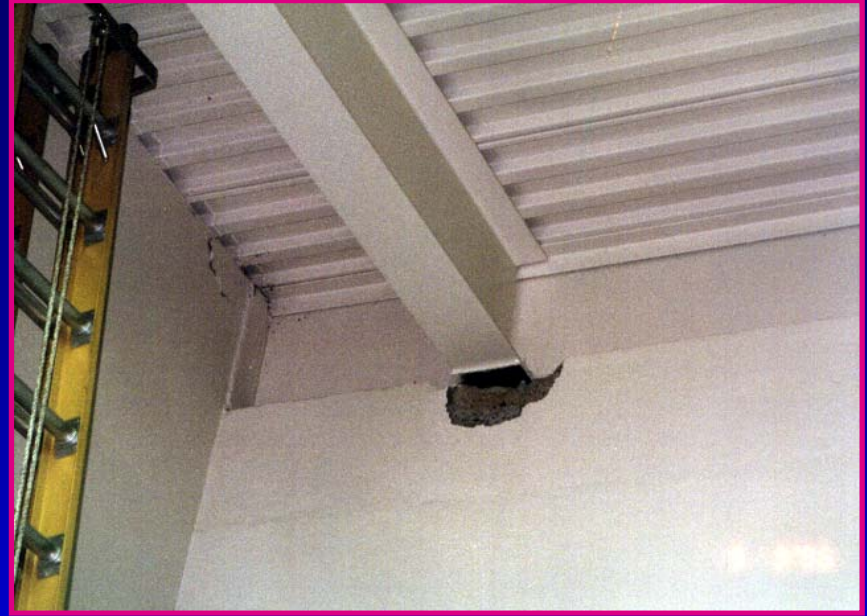


## Battery Hardening



## Miscellaneous Component Hardening

# BUILDINGS



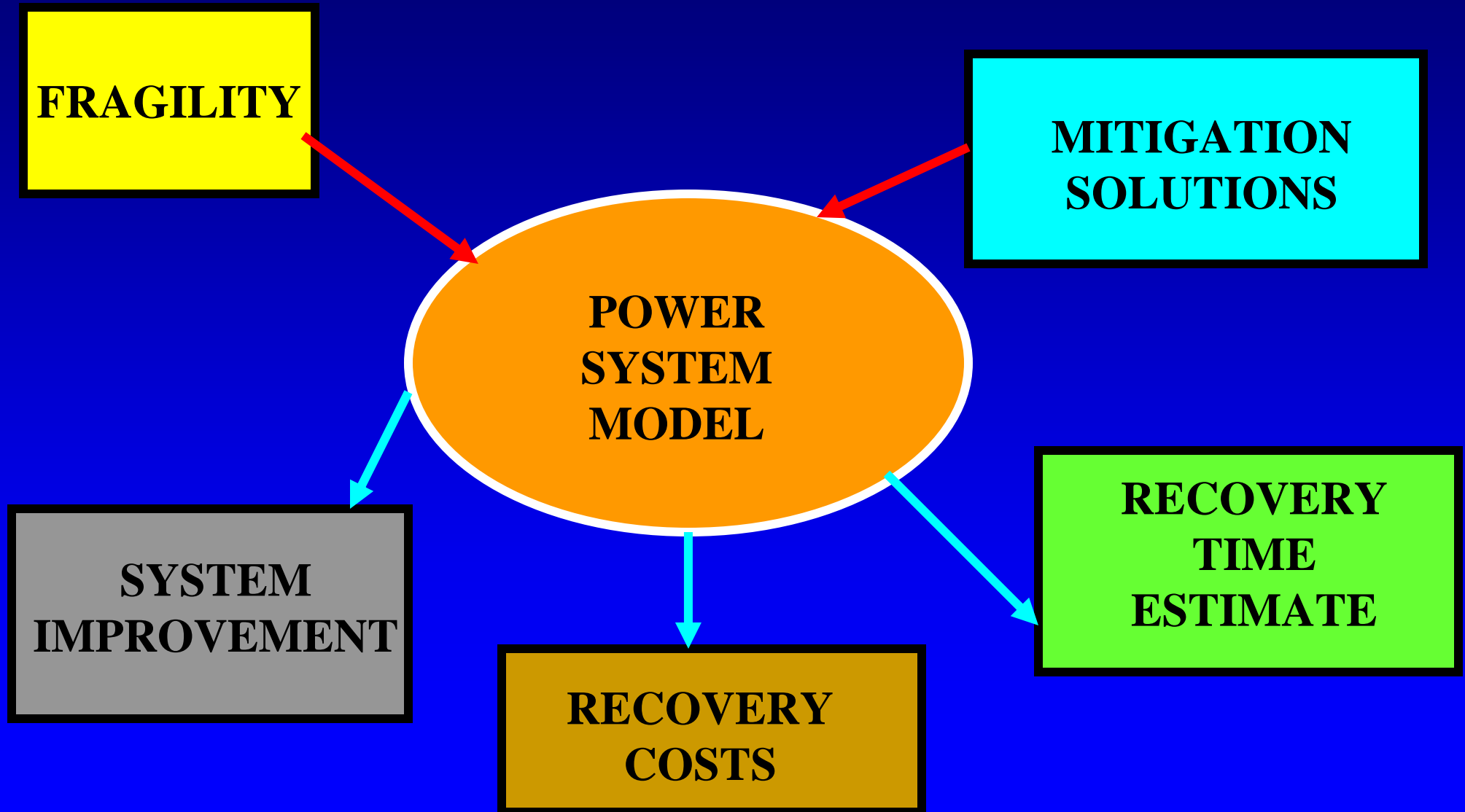
# Bushing Storage - Seismic Hardening



Unanchored



# Evaluation Tools to Assess Mitigation Solutions



# ACCEPTABLE PERFORMANCE OBJECTS

## Evaluation Tools to Assess Mitigation Solutions

FRAGILITY

MITIGATION  
SOLUTIONS

POWER  
SYSTEM  
MODEL

SYSTEM  
IMPROVEMENT

RECOVERY  
COSTS

RECOVERY TIME  
ESTIMATE

# EXISTING SUBSTATIONS: COST EFFECTIVE SOLUTIONS

