

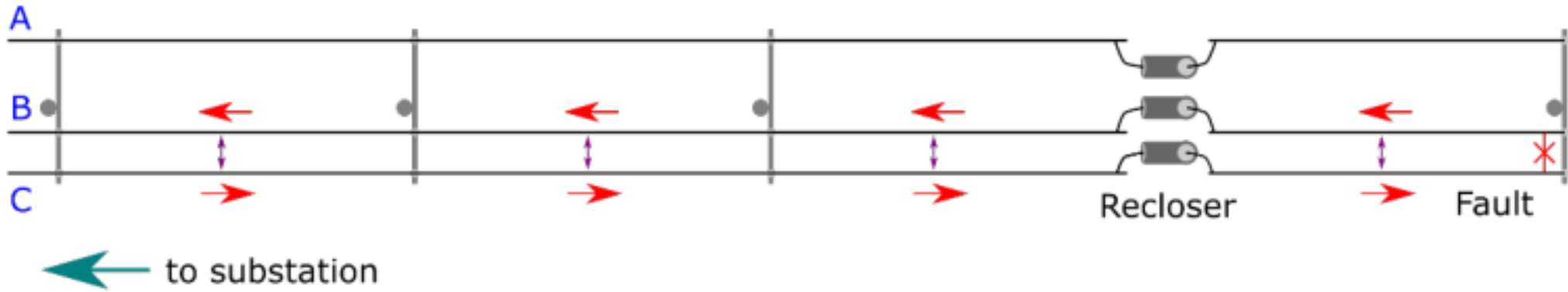
Conductor Slap

Tom Short

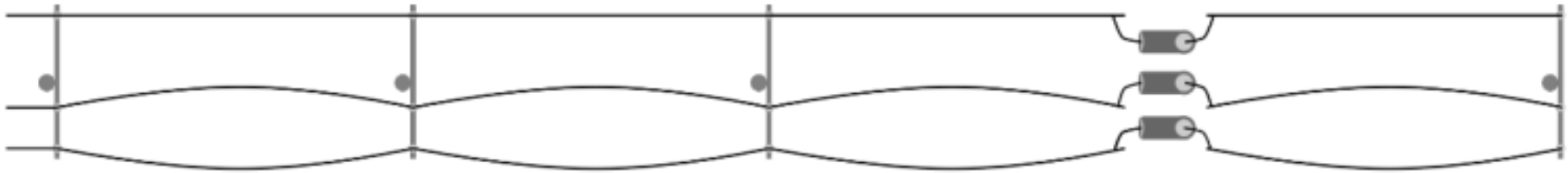
tshort@epri.com



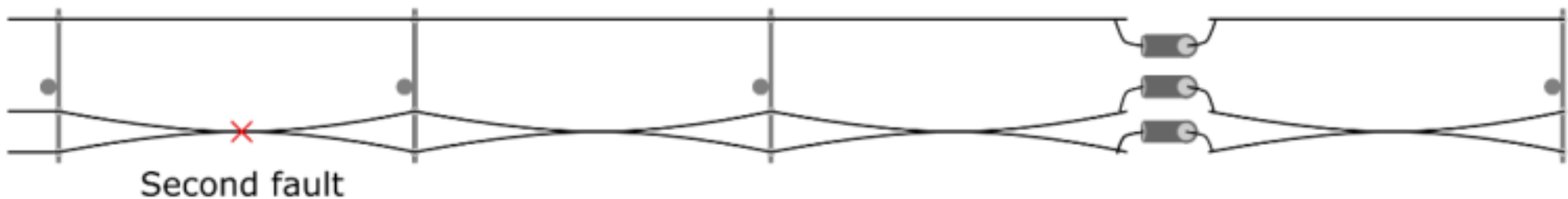
Conductor Slap



Conductors swing apart



Conductors swing back together



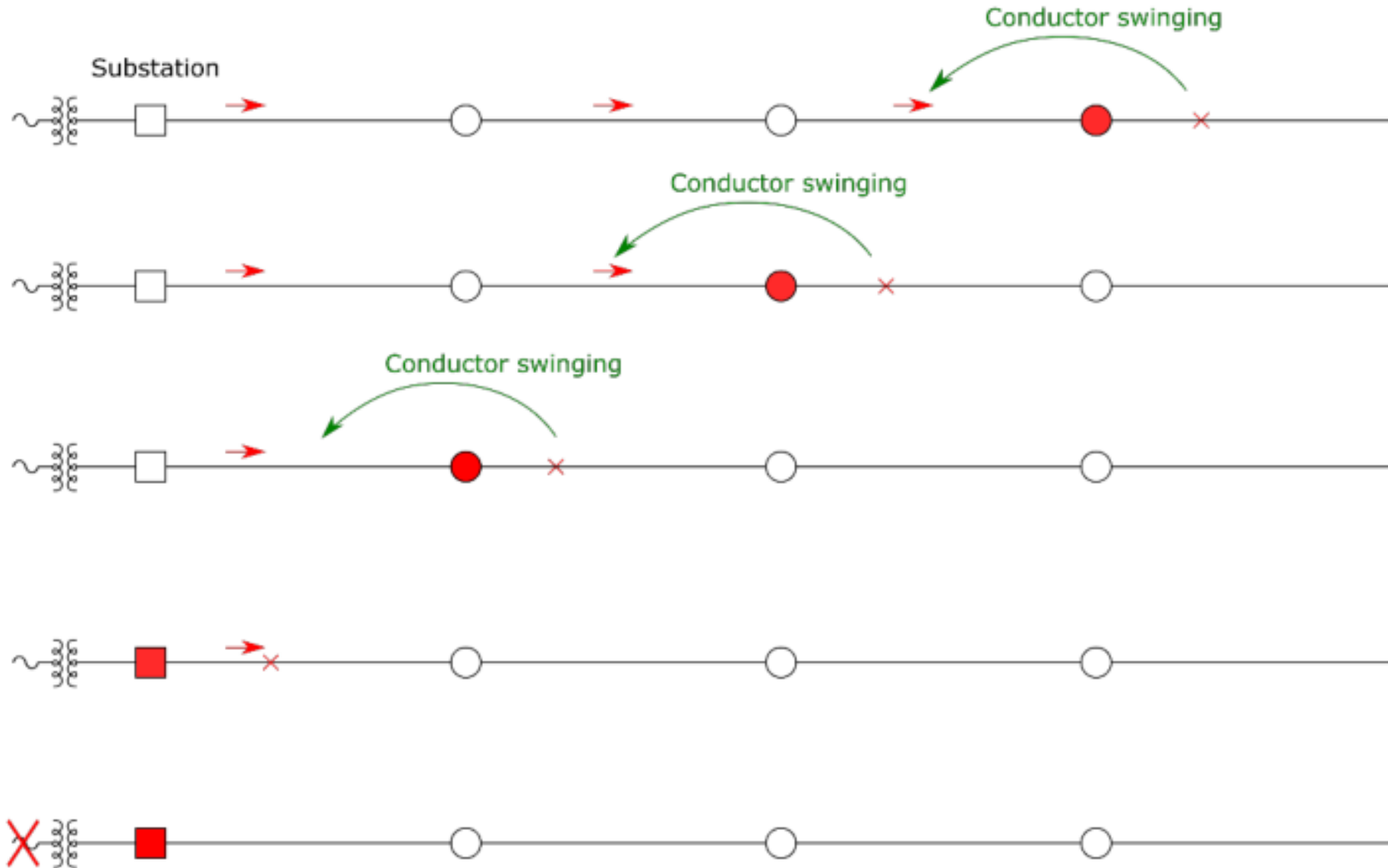








Marching Faults

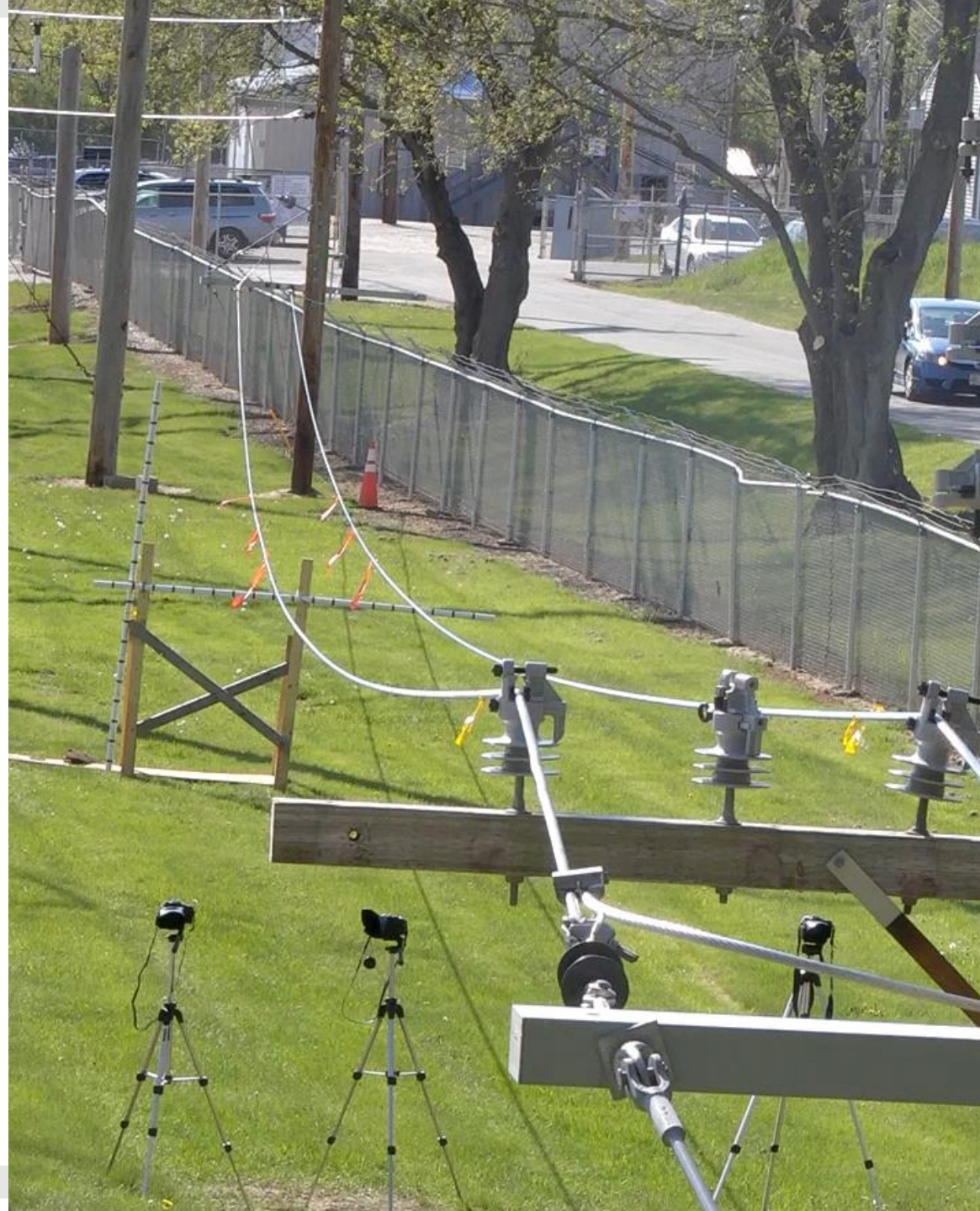


Main Variables Affecting Slap

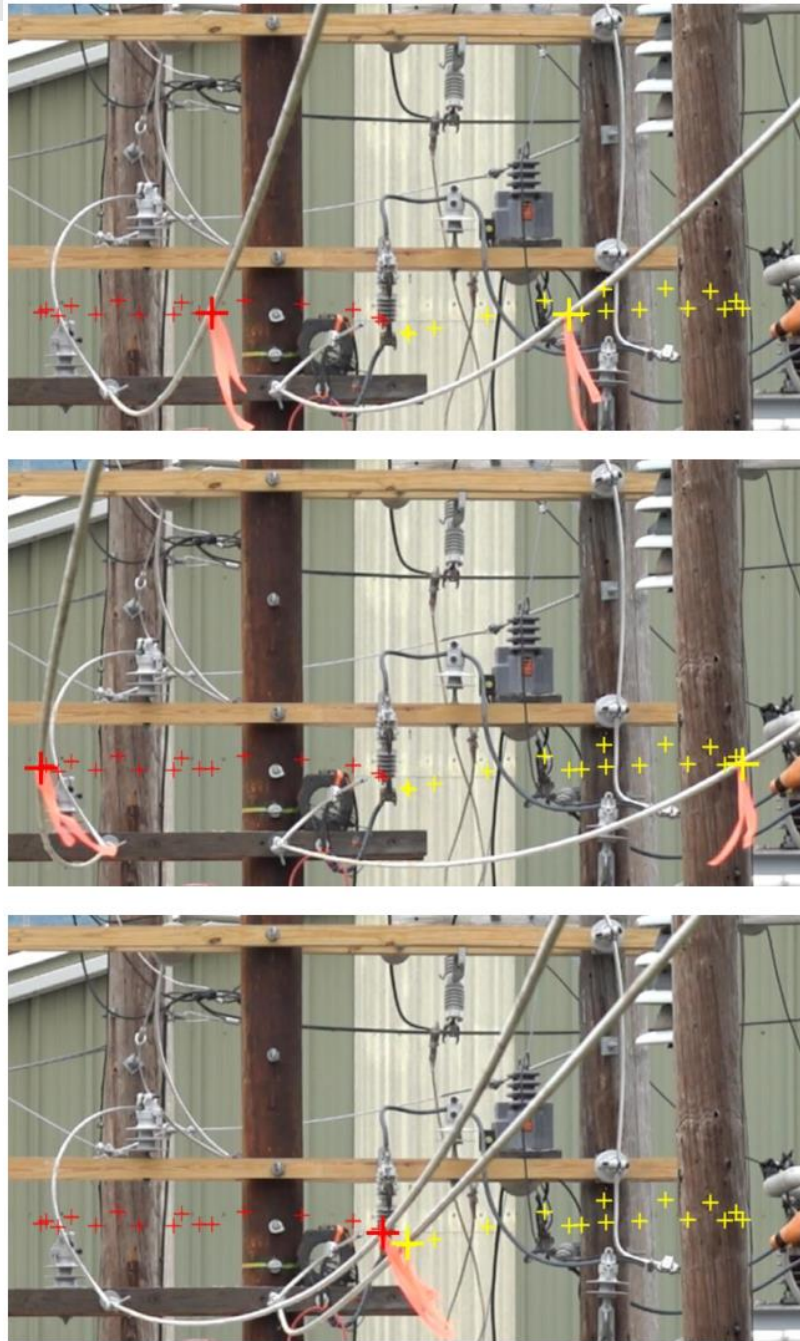
- Conductor spacing
- Fault current
- Fault duration
- Conductor size
- Span length
- Conductor sag / tension

Testing





Horizontal Design



Event 10255: $I = 2958 \text{ A}$; $t = 27 \text{ cycles}$; horizontal separation = 29 in;
sag = 24 in; span = 200 ft; 336 ACSR

Vertical Design



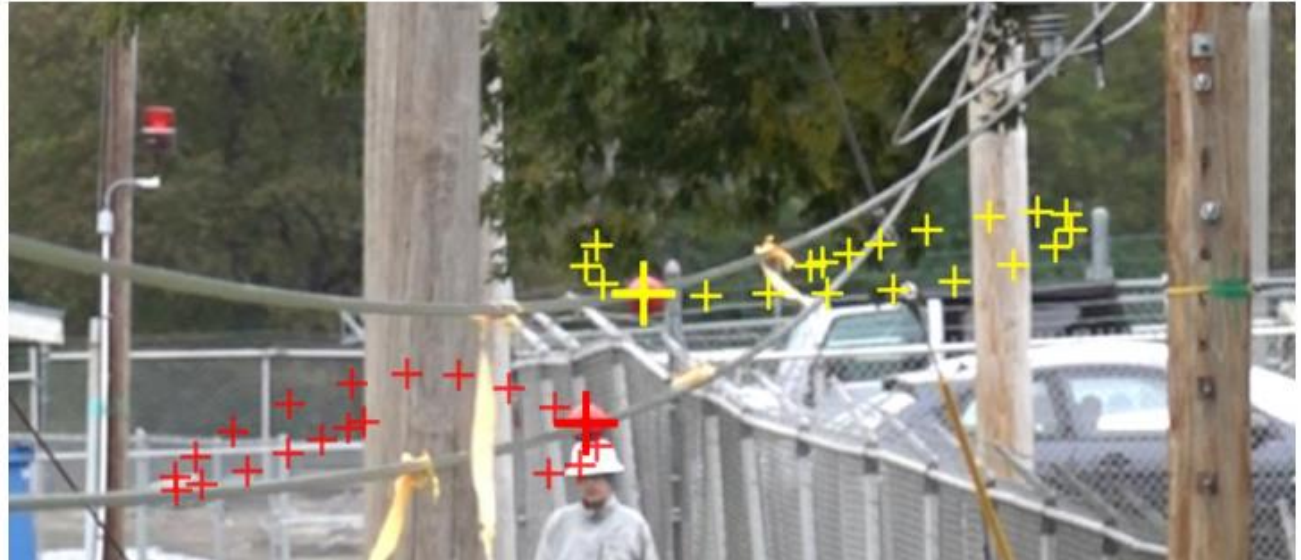
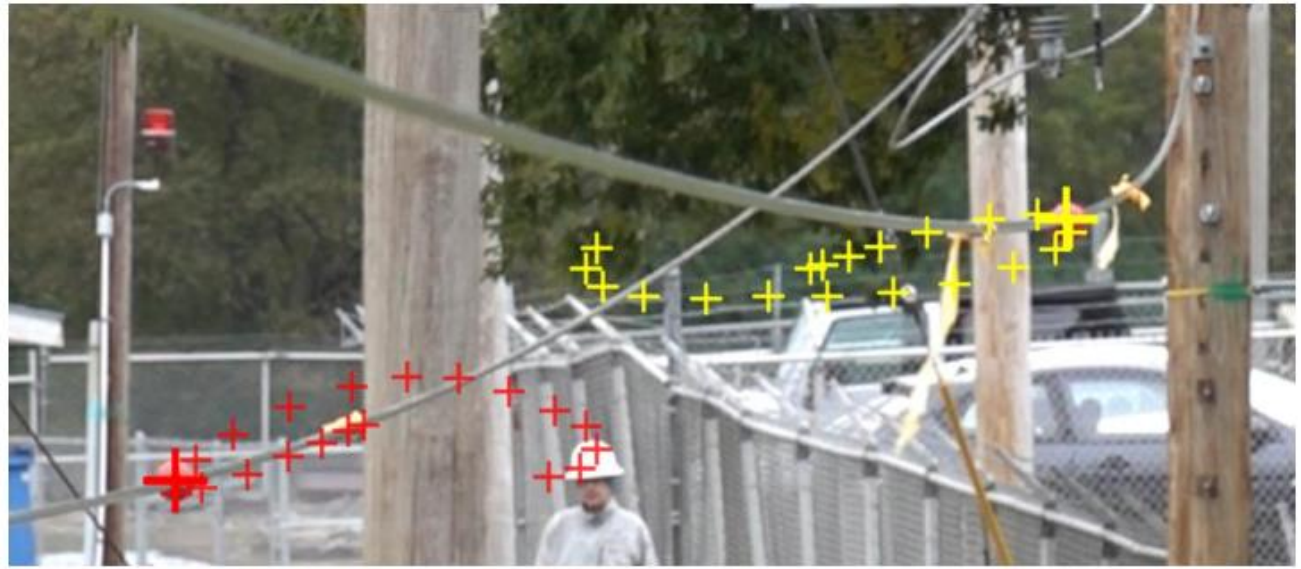
Event 10290: $I = 2955 \text{ A}$; $t = 27 \text{ cycles}$; vertical separation = 30 in
span = 200 ft; sags = 24 in; 336 ACSR

Horizontal w/ Vertical Offset



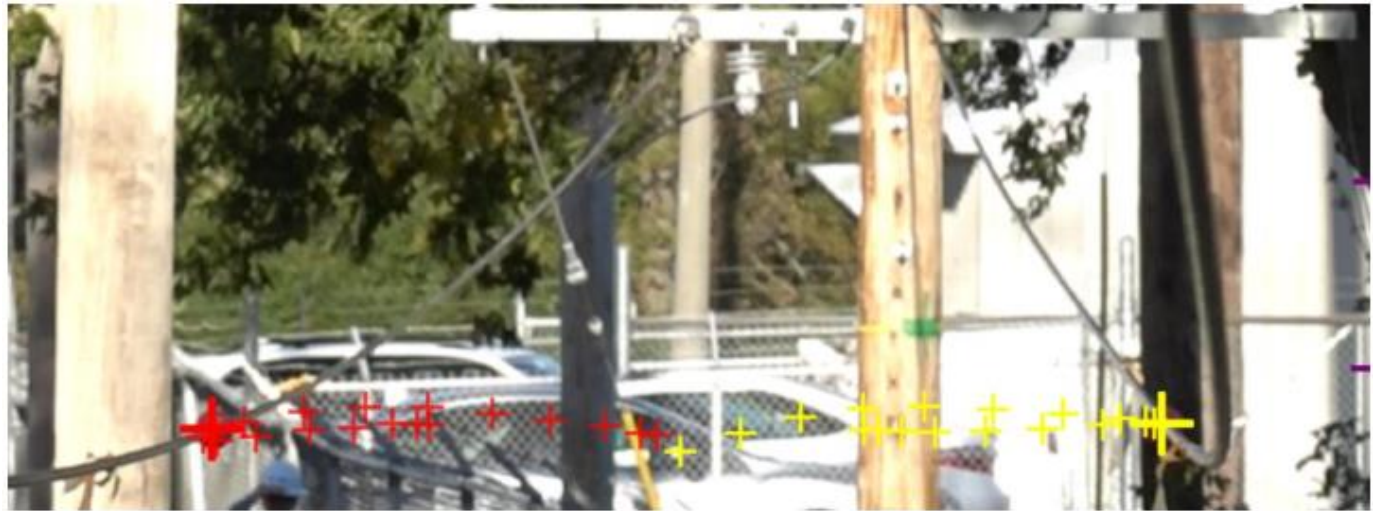
Event 10416: $I = 2635 \text{ A}$; $t = 27 \text{ cycles}$; horizontal separation = 29 in;
span = 290 ft; sags = 36 in; 336 ACSR

Horizontal w/ Vertical Offset



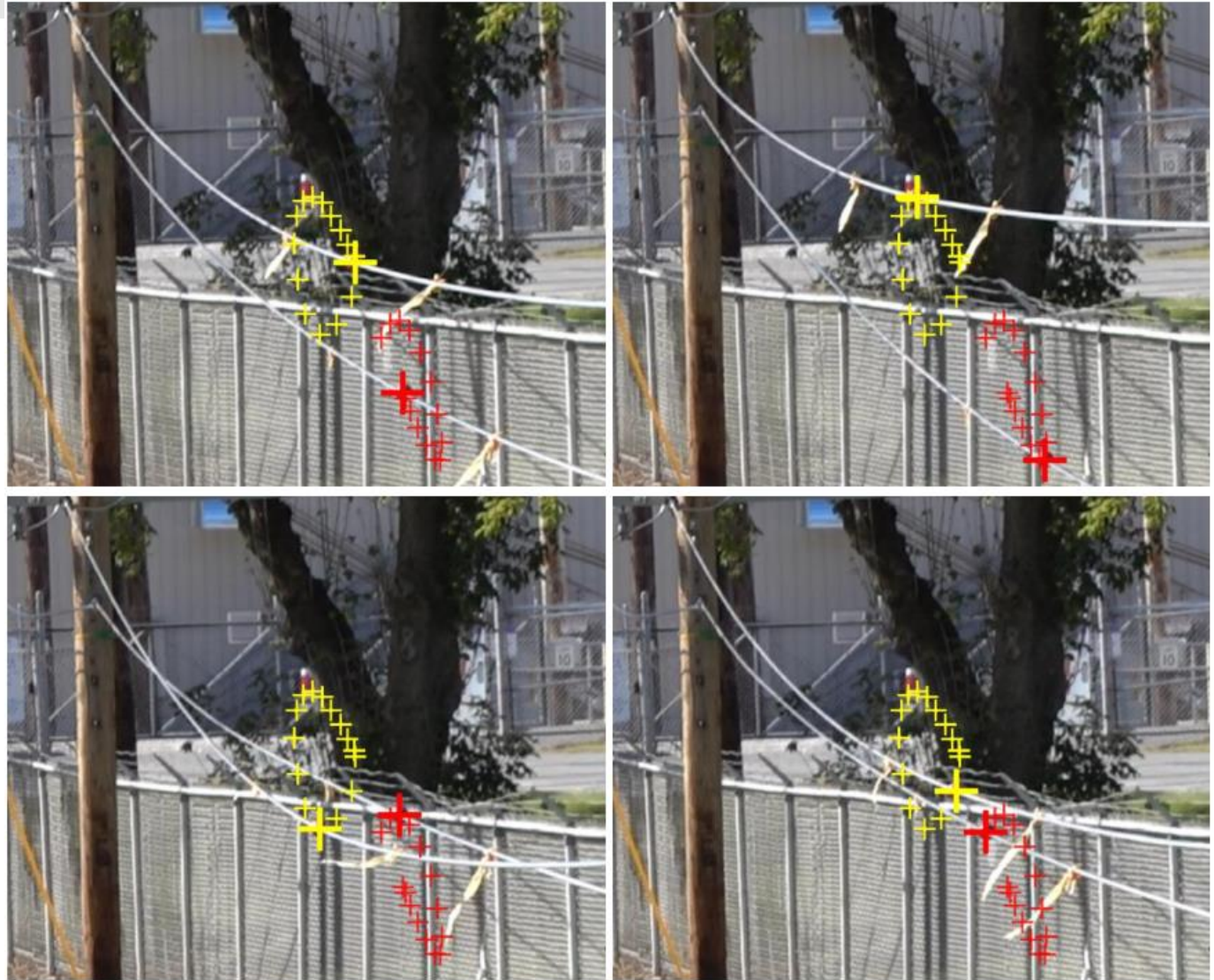
Event 10419: $I = 2633 \text{ A}$; $t = 27 \text{ cycles}$; horizontal separation = 29 in;
span = 290 ft; sags = 36 in; 336 ACSR

Horizontal w/ Vertical Offset & Unequal Sags



Event 10422: $I = 2613 \text{ A}$; $t = 27 \text{ cycles}$; horizontal separation = 29 in;
span = 290 ft; left sag = 36 in; right sag = 48 in; 336 ACSR

Vertical w/ Offset



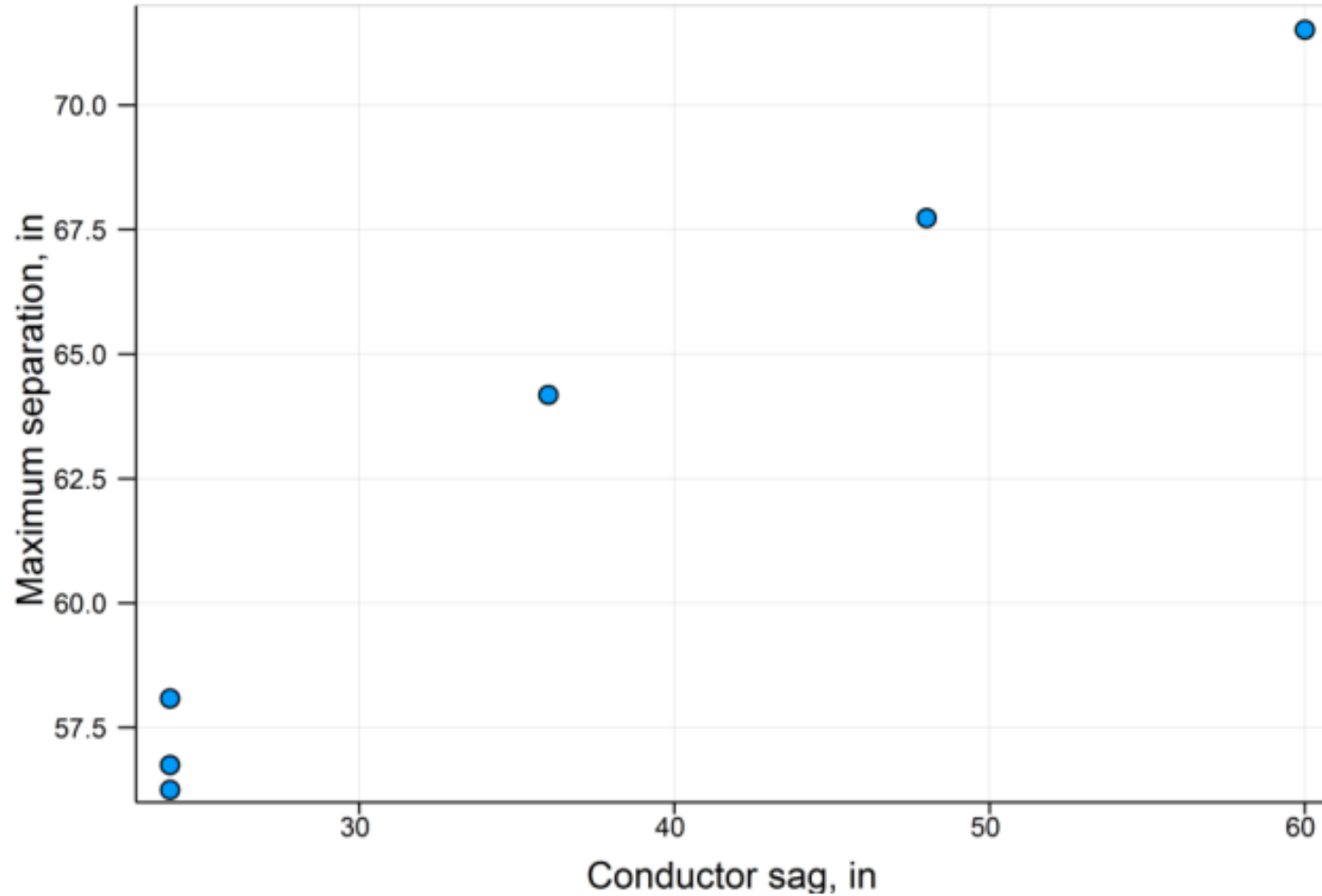
Event 10447: $I = 2635$ A; $t = 27$ cycles; span = 290 ft; 336 ACSR
vertical separation at ends = 30 in
vertical separation in the middle = 18 in
horizontal separation = 6 in
top sag = 48 in; bottom sag = 36 in

Transition Spans

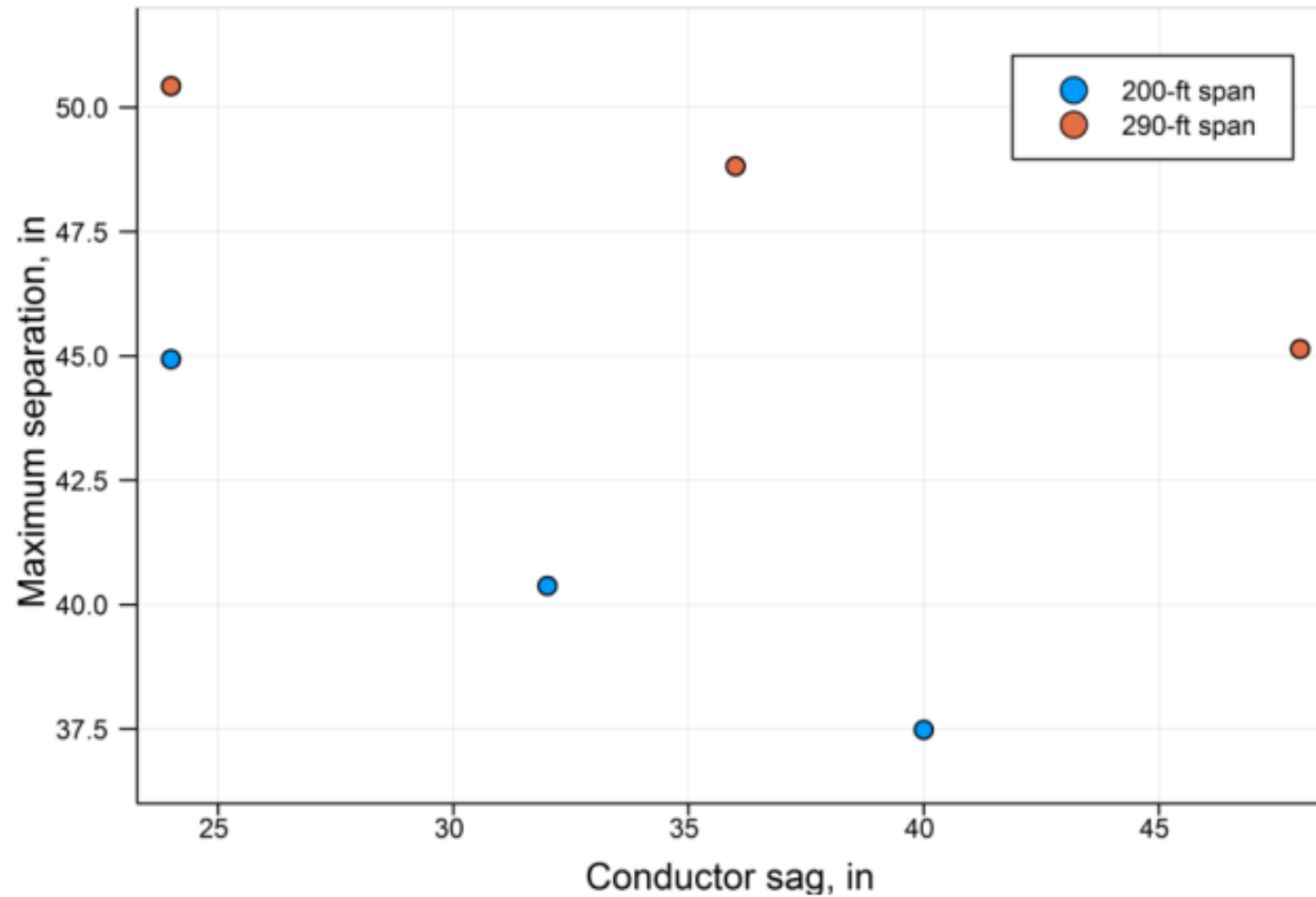


Event 10435: $I = 2632$ A; $t = 27$ cycles; span = 290 ft; 336 ACSR; sags = 36 in
vertical separation on the far end = 30 in
horizontal separation on the near end = 29 in

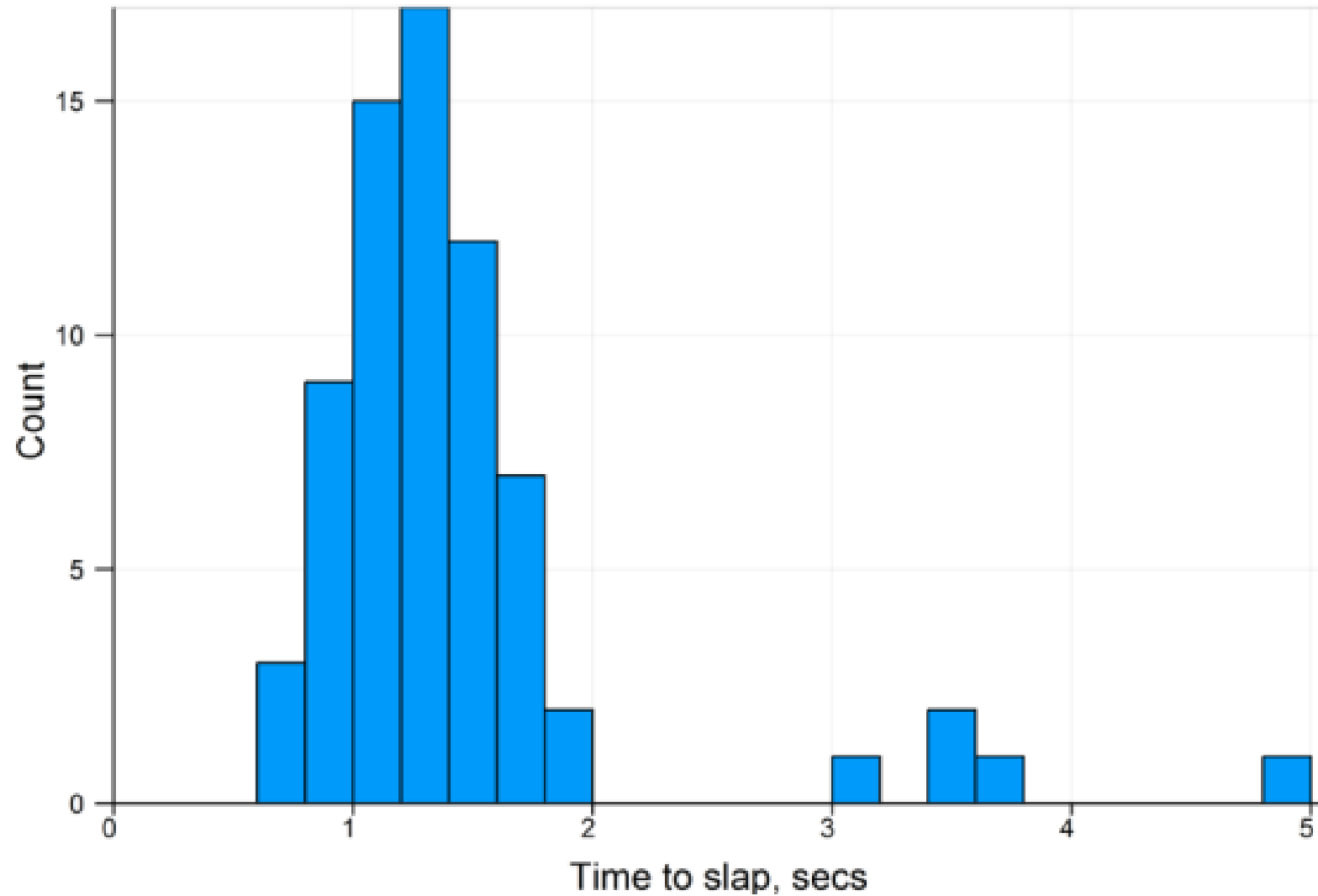
Impact of Conductor Sag: Horizontal Design



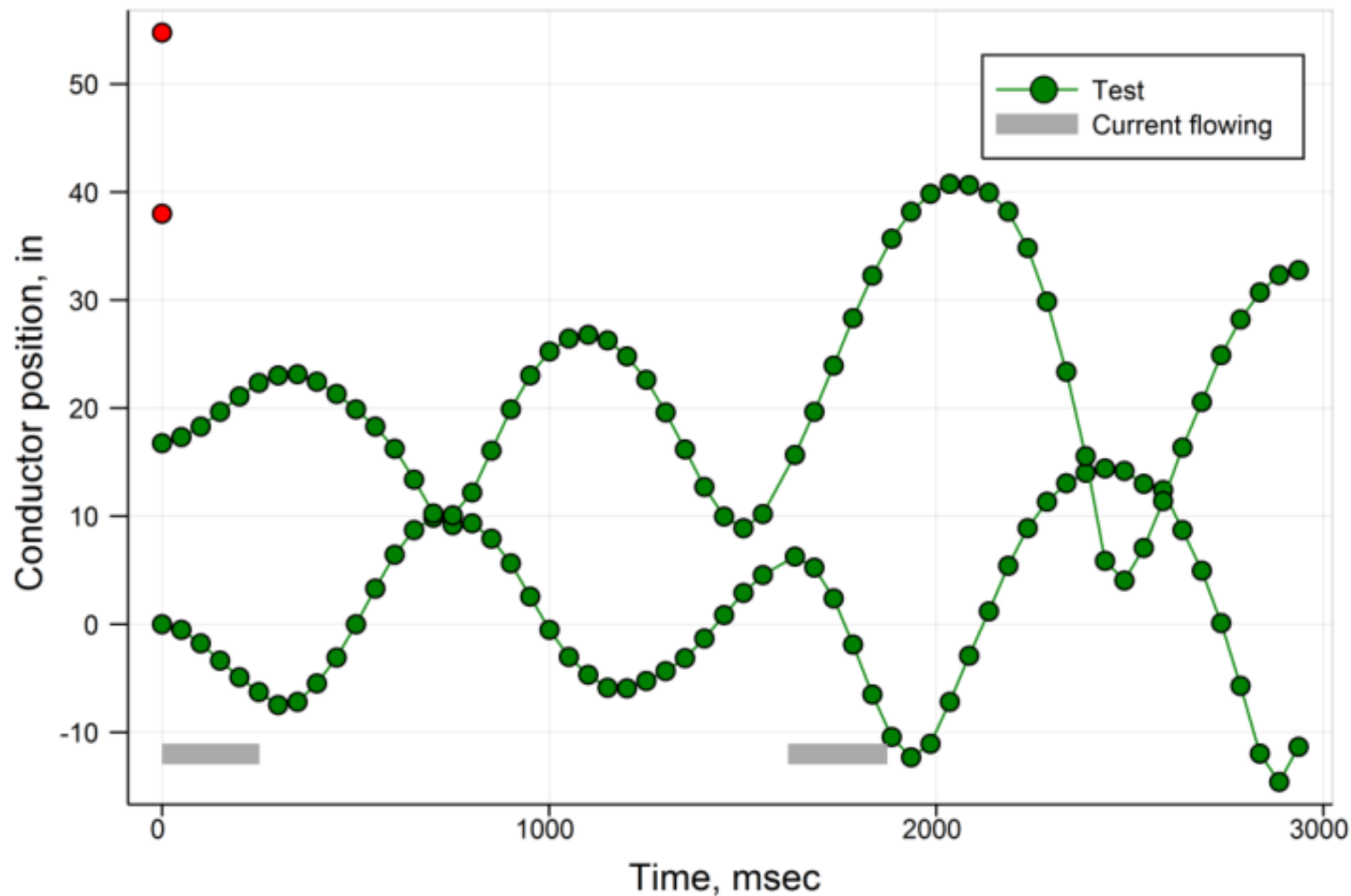
Impact of Conductor Sag: Vertical Design



Time to Slap

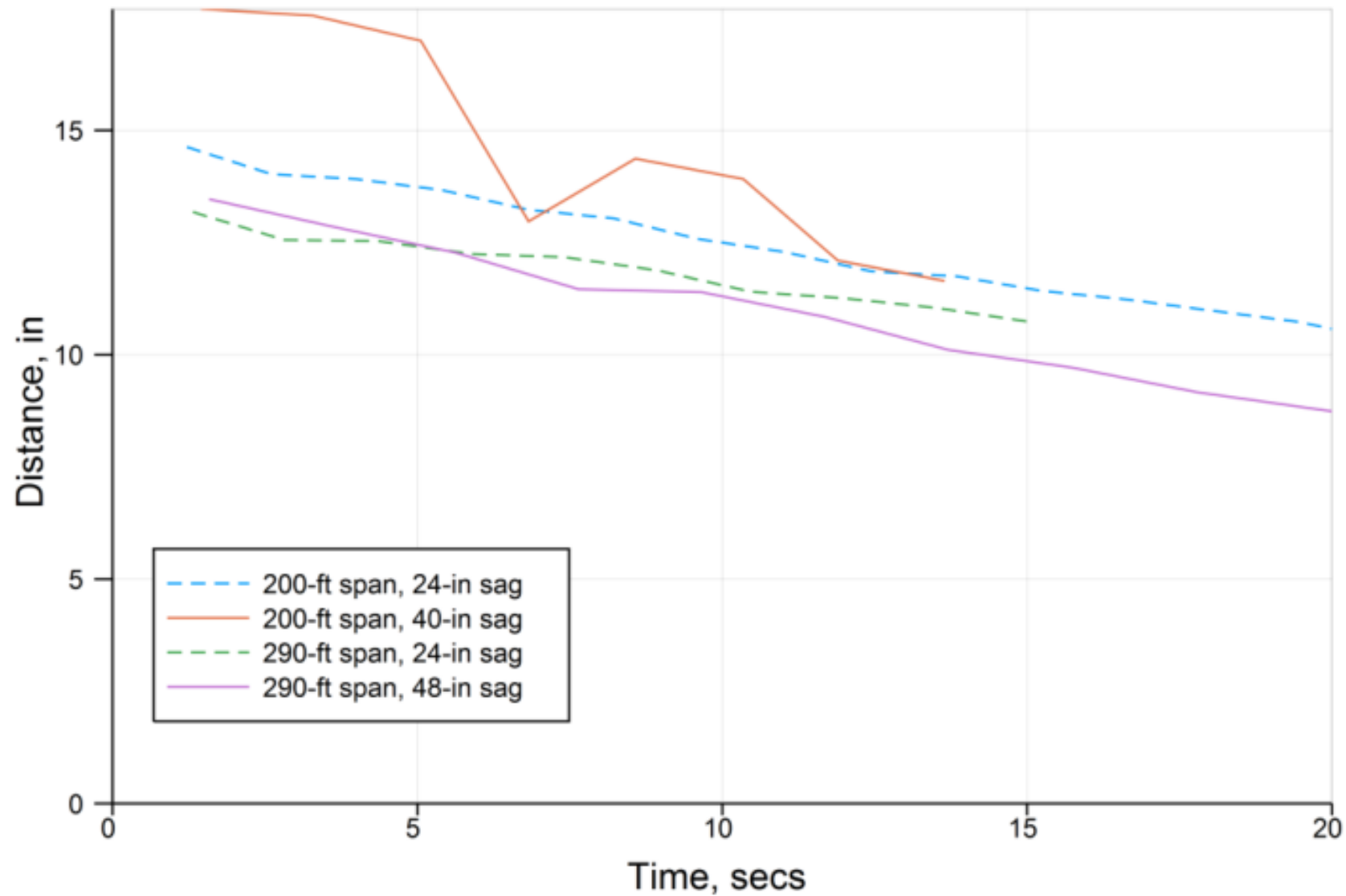


Reclosing

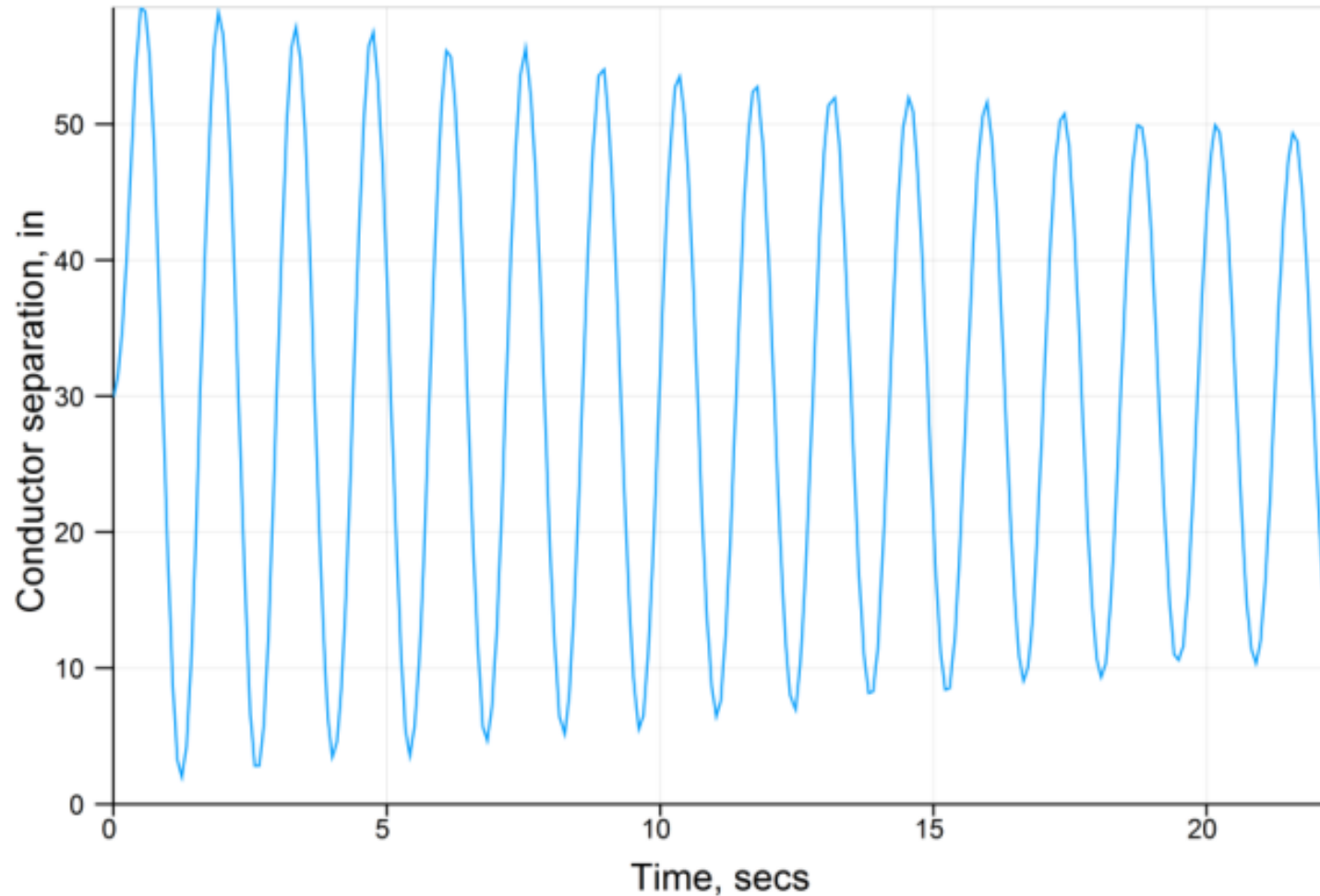


Event 10306: $I = 2956$ A; $t_1 = 15$ cycles; $t_2 = 15$ cycles; reclose at 1.6 secs
vertical separation at ends = 30 in;
vertical separation at midspan = 16 in;
sag = 38 and 24 in; span = 200 ft; 336 ACSR

Decay of Swinging



Decay of Swinging Example



Event 10255: $I = 2958$ A; $t = 27$ cycles; horizontal separation = 29 in;
sag = 24 in; span = 200 ft; 336 ACSR

Solution Options

Retrofit

- Spacers
- Faster fault clearing
 - Better coordination
- Adjust reclosing
- Phase rotation

New designs

- Span length
- Sag/tension
- Horizontal separation
- Vertical separation
- Covered conductors

Spacers



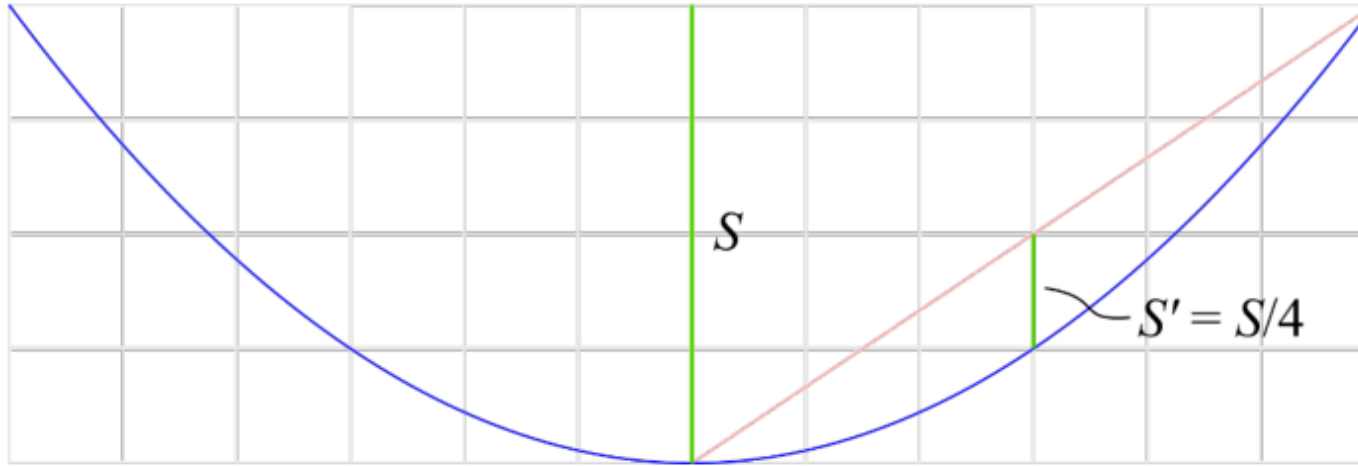
Spacers





Modeling the Effect of Spacers

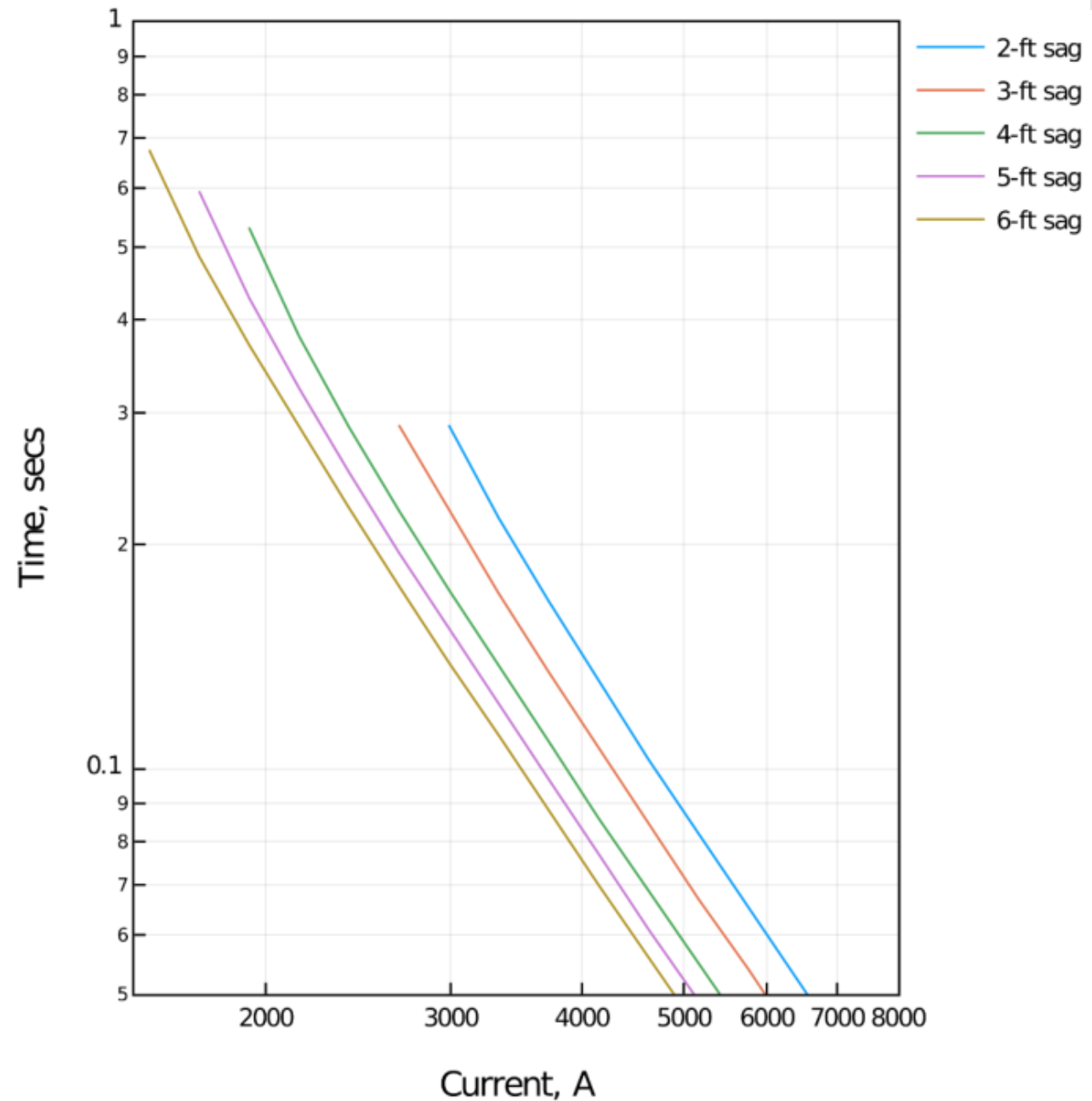
One set of midspan spacers:



Two sets of spacers:



Protection & Coordination



Horizontal separation = 29 in, 336 ACSR

Protection Options

- Tighten curves
- Negative-sequence relaying
- Adaptive relaying
- Reclosing
- Use reclosers like sectionalizers

