Power Outages in the Dec 20 2022 Ferndale Earthquake

John Eidinger, G&E Engineering Systems Inc.

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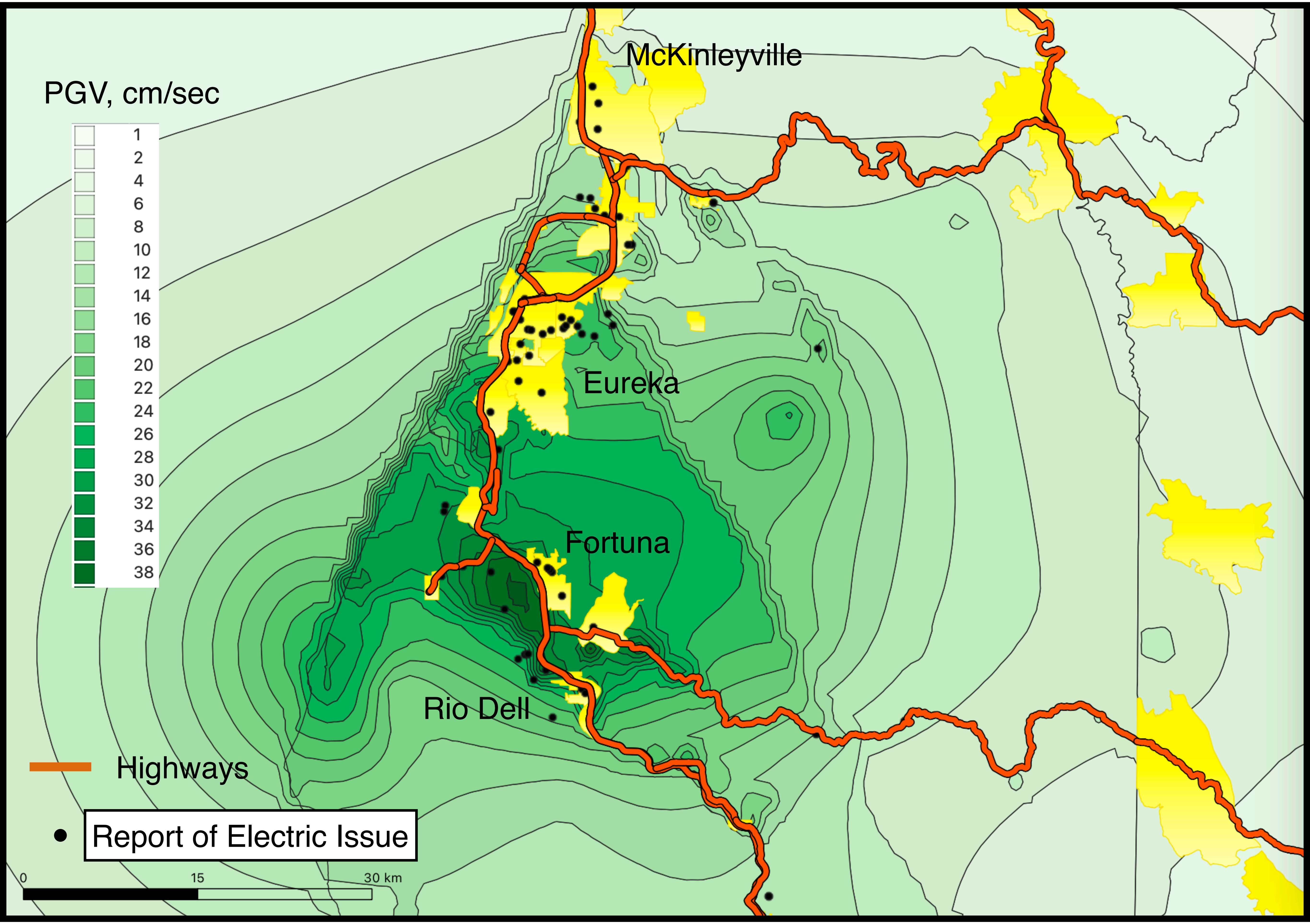


McKinleyville
PGV, cm/sec
1
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
Eureka
Fortuna
Rio Dell
Highways
Report of Electric Issue
0
15
30 km

Power Outages

- 70,000 customers immediately lose power
- Represents 100% of community that was exposed to PGA = 0.02g to 0.60g+
- < 5,000 customers lost power due to something physically breaking (wire down, etc.) (35 instances)
- >65,000 customers lost power due to phase-to-phase or phase-to-ground faults

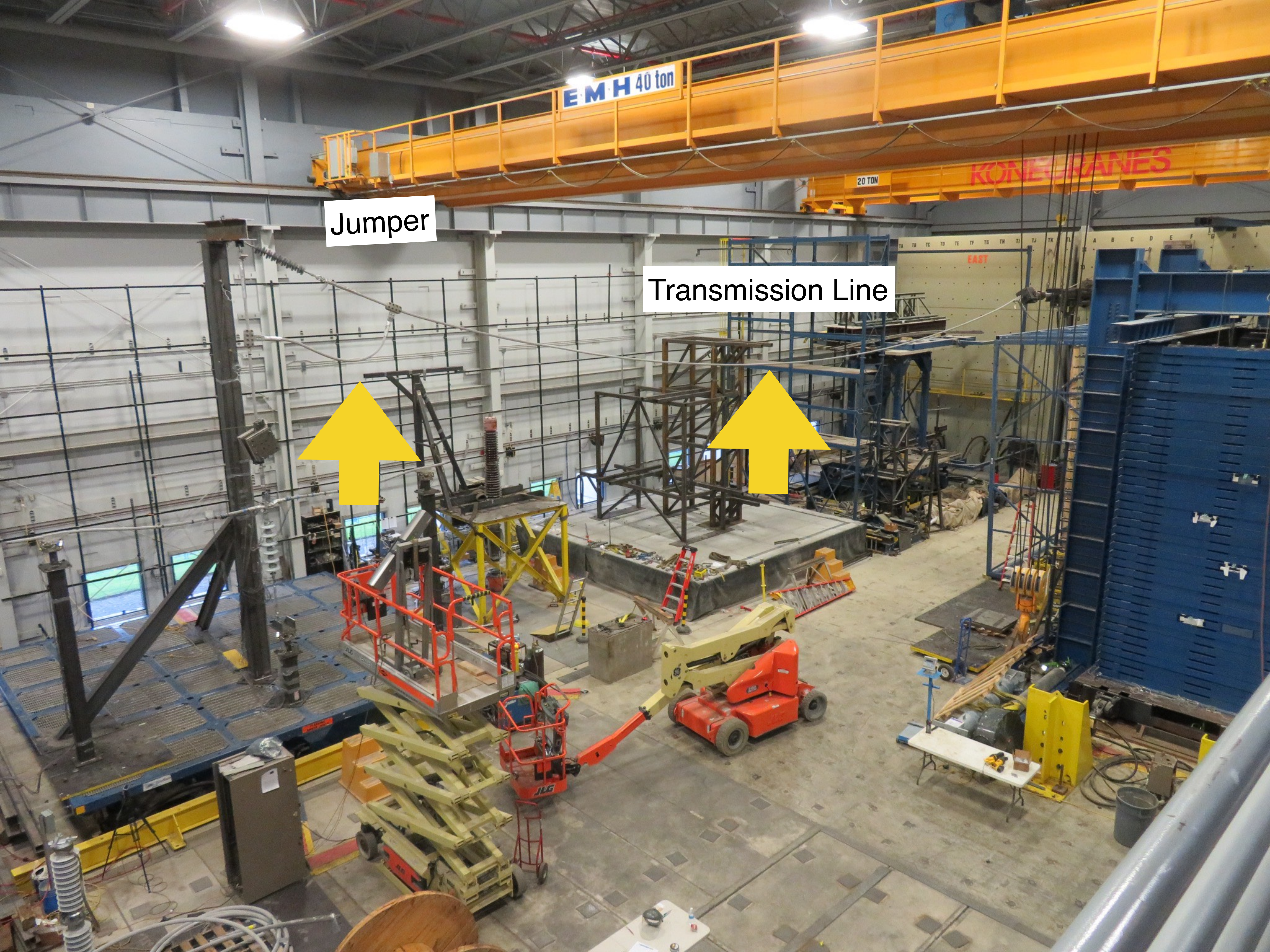
Phase to Phase / Ground Faults

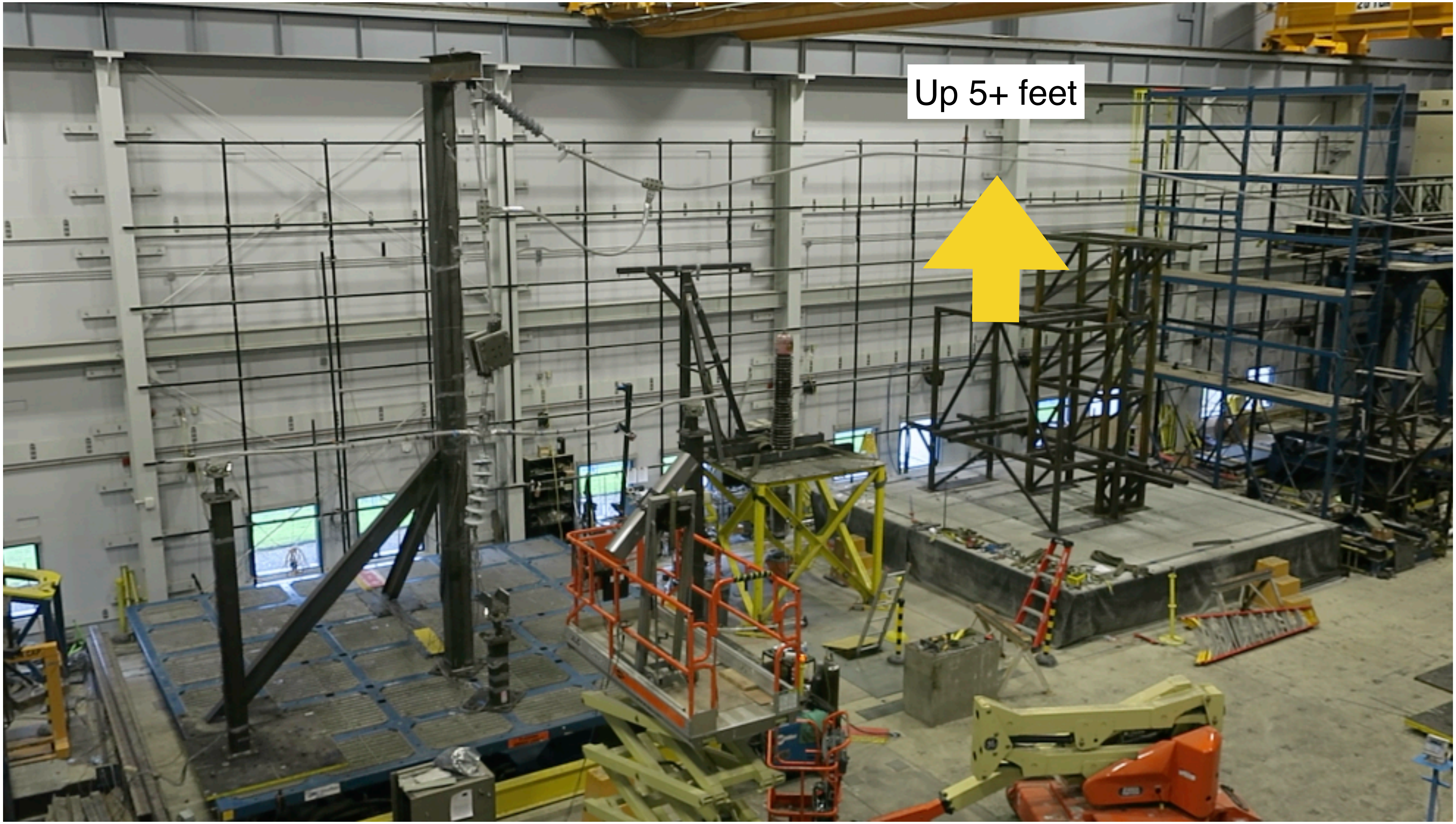
- Shaking causes towers / poles to vibrate, which in turn cause conductors to oscillate
- Nearly all circuits have 3 phases
- If wires swing out-of-sync and get too close to neighboring phase, the line "faults", a circuit breaker opens, and there is a power outage
- Statistical evaluations show that about 1 / 1000 spans (between two poles or towers) had phases that faulted. Faults occurred at PGA > 0.4g, and PGA < 0.05g

-- TABLE 42A --------------------------------

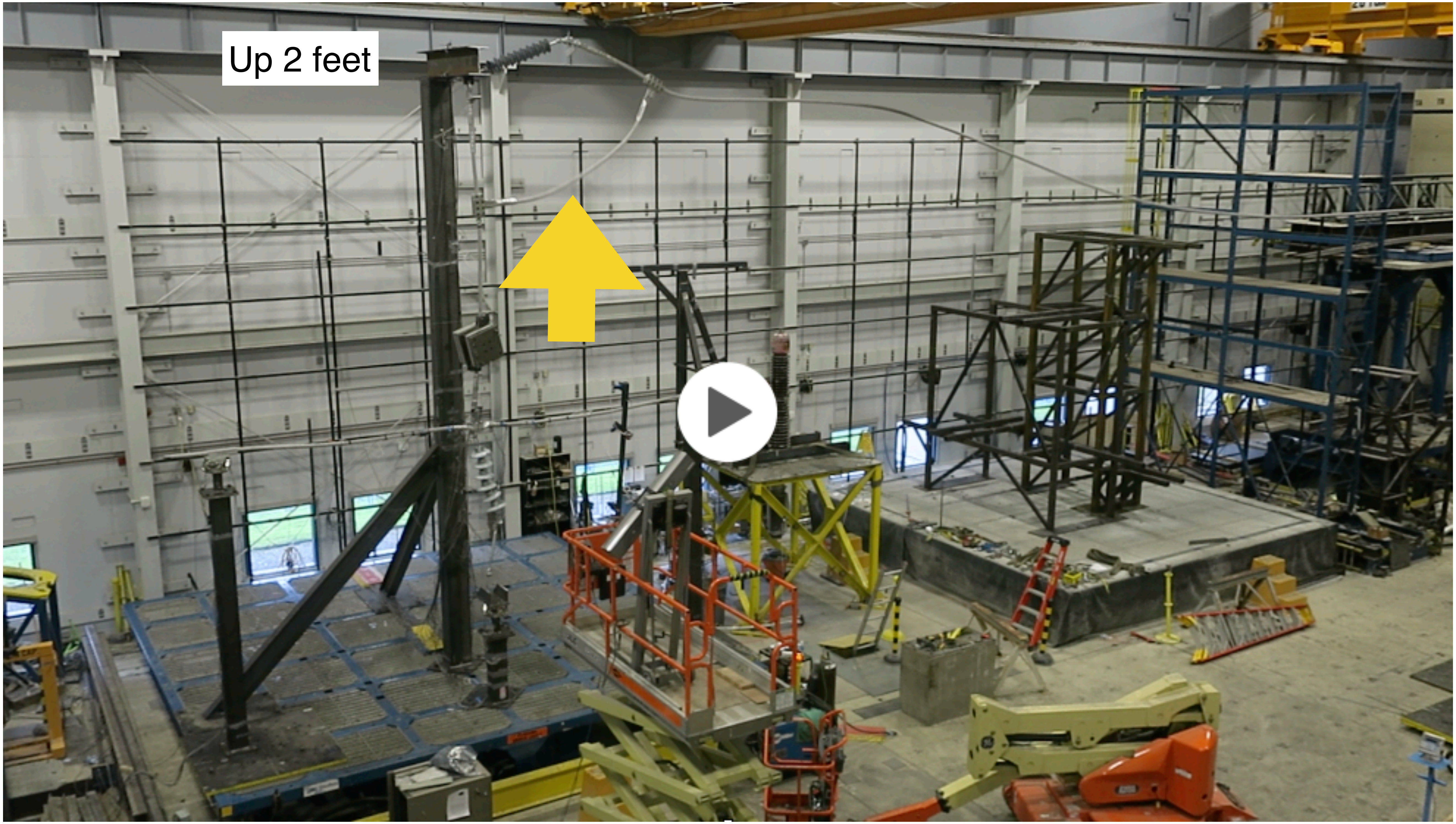
Number of Towers / Poles

HAZARD RANGE	Number of Transmission Spans	Number of Faults
PGA = 0.010 to 0.049 g	4174	4
PGA = 0.050 to 0.099 g	1530	
PGA = 0.100 to 0.149 g	527	
PGA = 0.150 to 0.199 g	383	
PGA = 0.200 to 0.249 g	255	
PGA = 0.250 to 0.299 g	480	2
PGA = 0.300 to 0.349 g	136	
PGA = 0.350 to 0.399 g	95	
PGA = 0.400 to 0.449 g	53	
PGA = 0.450 to 0.499 g	71	
PGA = 0.500 to 0.549 g	56	
PGA = 0.550 to 0.599 g	33	
PGA = 0.600 to 0.649 g	17	

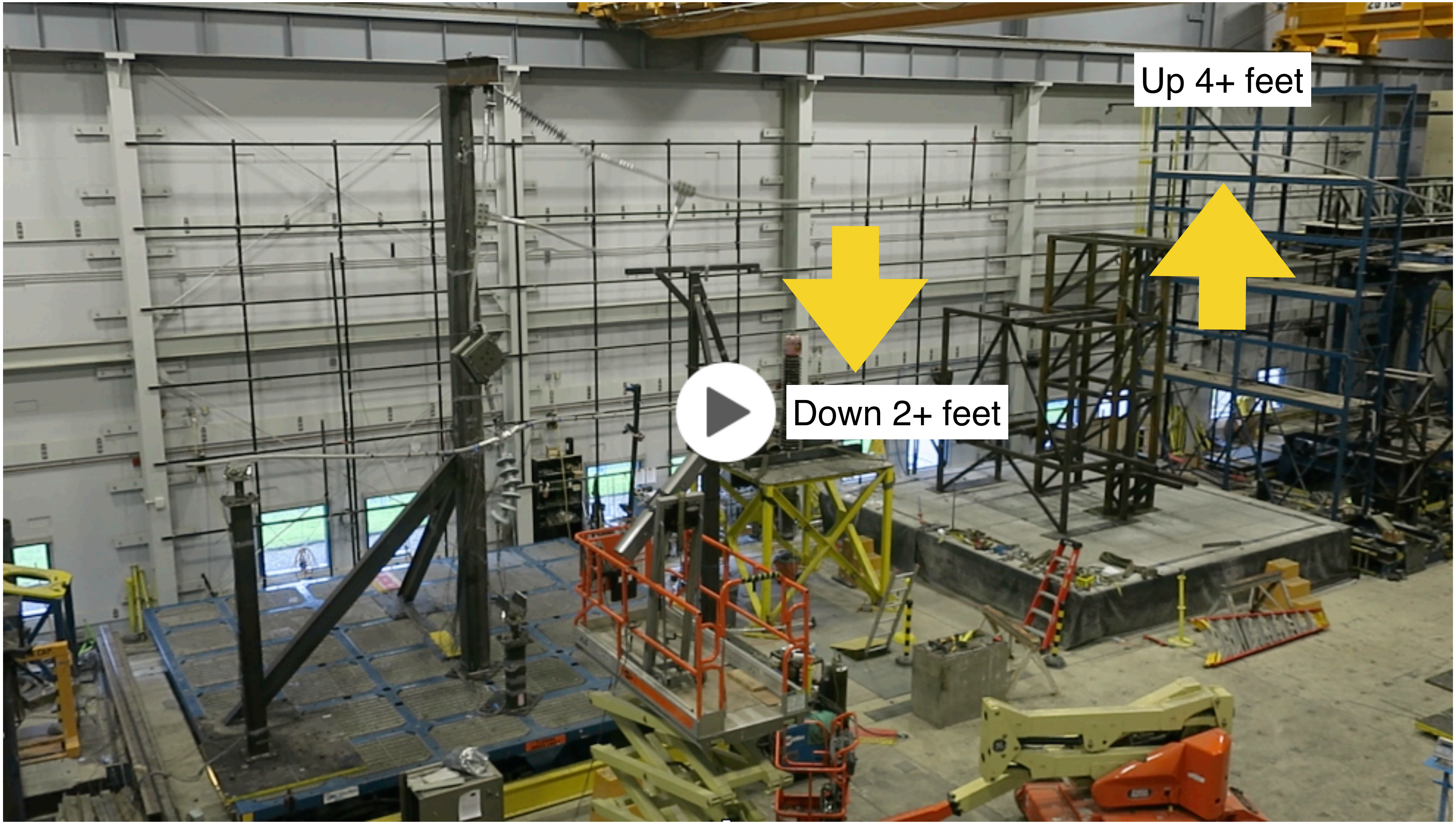

EMH 40 ton
KONECRANES
20 TON
Jumper
Transmission Line
EAST



Test S18. IEEE 693 Qualification Spectra (3D) Bluebird Conductor.
Large slack (T-line). Tight Slack (Substation).



Test S18. Bluebird Conductor.
Large slack (T-line). Tight Slack (Substation).



Test S18. Bluebird Conductor.
Large slack (T-line). Tight Slack (Substation).

Conclusions

- 95% of power outages in M 6.4 Fortuna / Ferndale Earthquake were due to faults in the transmisson network
- Forecasting the phase-to-phase movement of power cables requires modest to high shaking coupled with out-of-sync conductor movements (about 2 to 3 sigma events). About 1 in 1,000 spans fault. This is RARE, but there are many thousands of exposed spans. 6 faults out of 7,000+ spans.
- To eliminate 95% of outages requires mitigation of the overhead conductors. We need long period ground time histories that account for basin effects and spatial time delay; plus structural models.