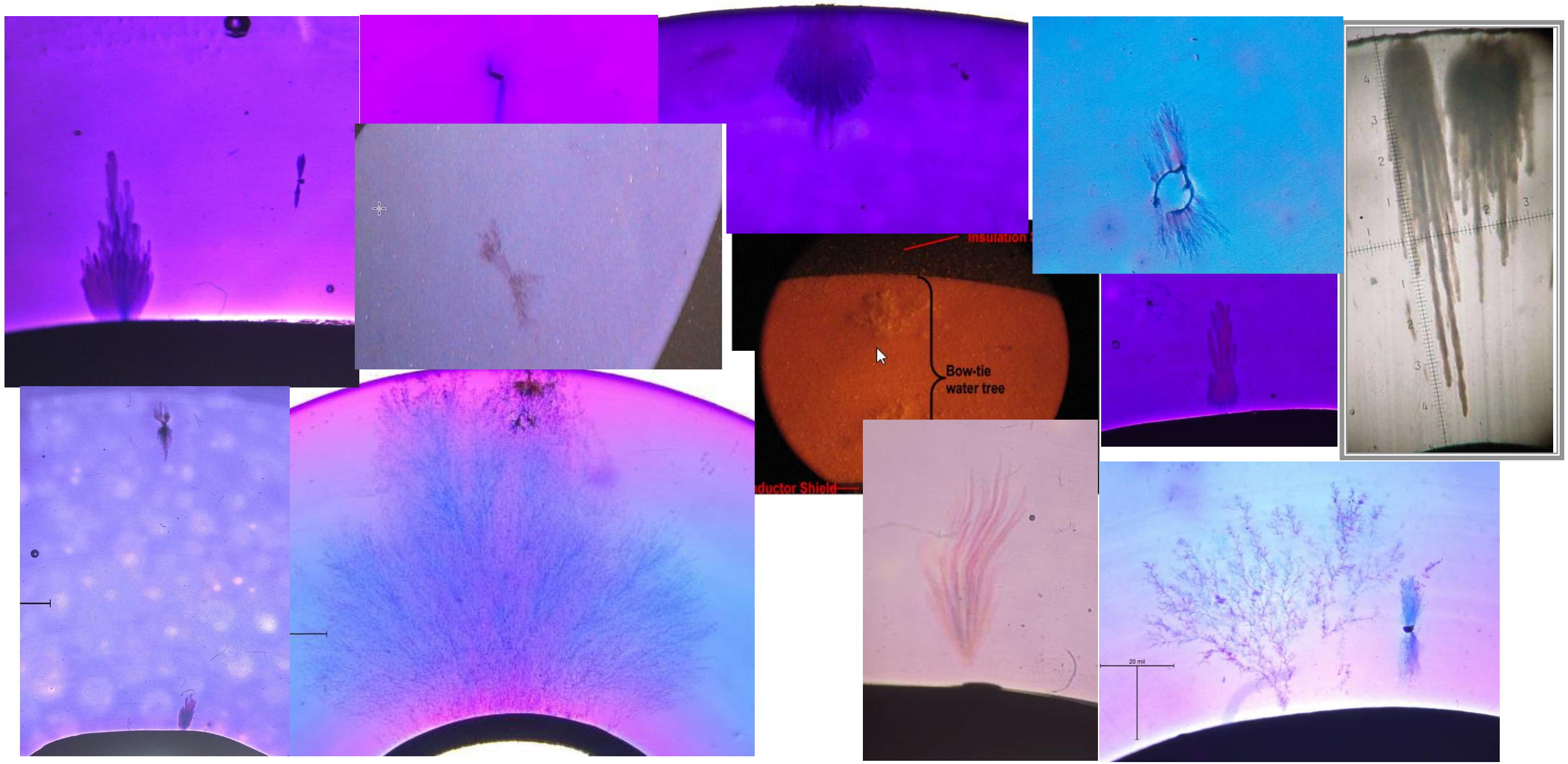
ELECTRIC POWER
RESEARCH INSTITUTE

Datamining Historical Reports of Service Performance

Josh Perkel, Dexter Lewis, Nigel Hampton

Water Trees observed in EPR, HMWPE, WTRXLPE, XLPE



What was the initial impact of Water Trees?

- When did it occur?
- How rapidly did it develop?
- How did it look at the time?

SUMMARY OF SERVICE FAILURE OF HIGH VOLTAGE EXTRUDED DIELECTRIC INSULATED CABLES IN THE UNITED STATES

J. H. Lawson
Pacific Gas and Electric Company
San Francisco, California 94106

and

W. A. Thue
Florida Power and Light
Miami, Florida

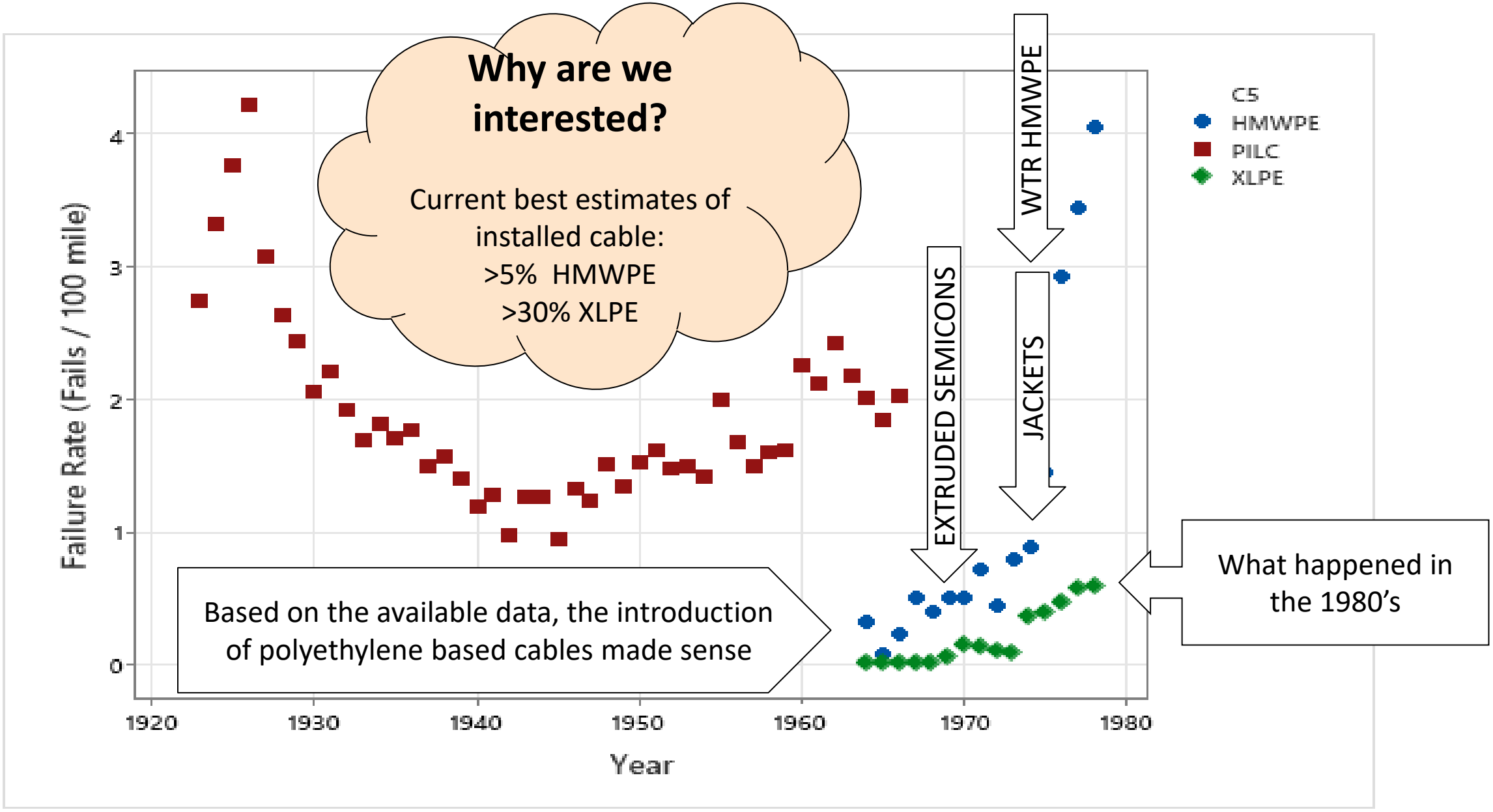
Comparative Failure Rates for 5-35 kV HMW and XLP Extruded Cables

	HIGH MOLECULAR WEIGHT POLYETHYLENE					CROSSLINKED POLYETHYLENE				
Year	Cumulative Cond. Miles	Annual Elec. Failures	Annual Rate	Cumulative Failures	Cumulative Rate	Cumulative Cond. Miles	Annual Elec. Failures	Annual Rate	Cumulative Failures	Cumulative Rate
1964	630.0	2	0.317	2	0.317	53.7	0	0.000	0	0.000
1965	1,281.6	1	0.078	3	0.234	156.9	0	0.000	0	0.000
1966	2,223.3	5	0.225	8	0.360	463.7	0	0.000	0	0.000
1967	3,373.1	17	0.504	25	0.741	1,342.7	0	0.000	0	0.000
1968	5,570.8	22	0.395	47	0.844	2,431.3	0	0.000	0	0.000
1969	8,259.8	42	0.508	89	1.078	4,128.2	2	0.048	2	0.048
1970	11,676.9	59	0.505	148	1.267	5,905.1	9	1.529	11	0.186
1971	16,340.5	117	0.716	265	1.622	8,137.4	11	0.135	22	0.270
1972	22,418.5	100	0.446	365	1.628	11,069.2	11	0.099	33	0.298
1973	28,916.4	230	0.795	595	2.058	15,491.7	14	0.090	47	0.303
1974	36,483.7	322	0.883	917	2.513	20,040.3	72	0.359	119	0.495
1975	40,141.2	582	1.450	1,499	3.734	23,941.6	93	0.388	212	0.885
1976	43,650.8	1,280	2.932	2,779	6.366	29,482.8	139	0.471	351	1.191
1977	47,043.7	1,622	3.448	4,401	9.355	35,857.4	206	0.574	557	1.533
1978	47,845.1	1,938	4.051	6,339	13.249	47,853.1	278	0.581	835	1.745

Over the last
been observed in hi
(HMW) and crosslink
cables removed from
failure rates of th
creasing and electr
as one of the major
concern for the rem
stalled cable due t

The advent, in
tial distribution s
truded dielectric c
U.S. utilities to c
new cables. By 197
extruded cables began to replace backbone paper insu-
lated cables. During the early 1970's isolated re-
whose quantity of cable reflected about 20% of the
total amount manufactured at that time.[1] Each year

Lawson & Thue – AEIC Data



Datamining

IEEE

POWER ENGINEERING SOCIETY

INSULATED CONDUCTORS COMMITTEE

MINUTES OF THE 81ST MEETING
ST. PETERSBURG, FLORIDA
NOVEMBER 8-11, 1987

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Datamining possible with skill
1947 – 2000
there is an Index for the Minutes

After 2000, it is a real slog
No Index for the Minutes

AEIC Reporting – huge kudos to Al Kong

1986 AEIC CABLE REPORT

HMWPE CABLE

CATEGORY			NUMBER FAILURES	TOTAL MILES	NUMBER UTILITIES	FAILURES PER 100 MILES
JACKETED	DUCT	< 40V/M	3	79	1	3.80
		> 40V/M	0	0	0	—
				0	0	—
				0	0	—
				13,313	4	1.20
				3,772	2	2.80
				6,412	8	10.90
				5,391	4	17.40

1986 AEIC CABLE REPORT

XLP CABLE

CATEGORY			NUMBER FAILURES	TOTAL MILES	NUMBER UTILITIES	FAILURES PER 100 MILES
JACKETED	DUCT	< 40V/M	21	22,927	7	0.10
		> 40V/M	15	8,985	12	0.20
	DB	< 40V/M	1	488	2	0.20
		> 40V/M	58	8,717	10	0.70
UNJACKETED	DUCT	< 40V/M	36	3,570	2	1.00
		> 40V/M	11	1,051	4	1.10
	DB	< 40V/M	35	2,561	3	1.40
		> 40V/M	835	21,712	12	3.90

What do they mean?

AEIC CABLE ENGINEERING SECTION QUESTIONNAIRE
TASK GROUP 25-AEIC
CABLE OPERATIONS REPORT

REPORTING UTILITY _____ BY _____ TEL NO. ( ) _____ DATE _____

A. CABLE INSULATION TYPE _____ (XLP, TRXLP, HMWPE OR EPR)

B. CABLE INSULATION THICKNESS _____ MILS

C. OPERATING VOLTAGE _____ KV (PHASE TO PHASE)

D. CABLE DATA:

INSTALLATION METHOD	CONDUCTOR FEET INSTALLED DURING 1986		CONDUCTOR FEET REMOVED OR ABANDONED DURING 1986		NUMBER OF ELECTRICAL FAILURES DURING 1986	
	JACKETED CABLE	UN-JACKETED CABLE	JACKETED CABLE	UN-JACKETED CABLE	JACKETED CABLE	UN-JACKETED CABLE
Cable in Duct						
Cable Pre-Installed in Conduit						
Cable Direct Buried						

E. SERVICE LIFE OF CABLES THAT FAILED DURING 1986 (YRS.): _____ MIN., _____ MAX., _____ AVG.

APPENDIX V-B-2

COMMENTS:

NOTES:
1. USE SEPARATE SHEET FOR EACH INSULATION TYPE, INSULATION THICKNESS AND OPERATING VOLTAGE.
2. Do not report data for cables rate below 5 kV (phase to phase).
3. Do not include dig-ins, splice or termination failures.
4. Indicate if the cables have insulating or semi-conducting jackets.
5. If you have any questions, please contact Albert Kong (415) 973-1708 or Greg Mastoras (205) 250-4327.

Please return the completed forms by August 3, 1987, to: Albert Kong
Pacific Gas and Electric Company
123 Mission Street, Room H1635
San Francisco, California 94106

Cable only

Extracting Failure Rates

1986 AEIC CABLE REPORT

1.54
1.45 / 100 miles
1.36

Confidence Range on the Failure Rate Estimate

XLP CABLE

CATEGORY			NUMBER FAILURES	TOTAL MILES	NUMBER UTILITIES	FAILURES PER 100 MILES
JACKETED	DUCT	< 40V/M	21	22,927		0.10
		> 40V/M	15	8,985		0.20
	DB	< 40V/M	1	488		0.20
		> 40V/M	58	8,717	10	0.70
UNJACKETED	DUCT	< 40V/M	36	3,570	2	1.00
		> 40V/M	11	1,051	4	1.10
	DB	< 40V/M	35	2,561	3	1.40
		> 40V/M	835	21,712	12	3.90

0.27
0.17
0.09

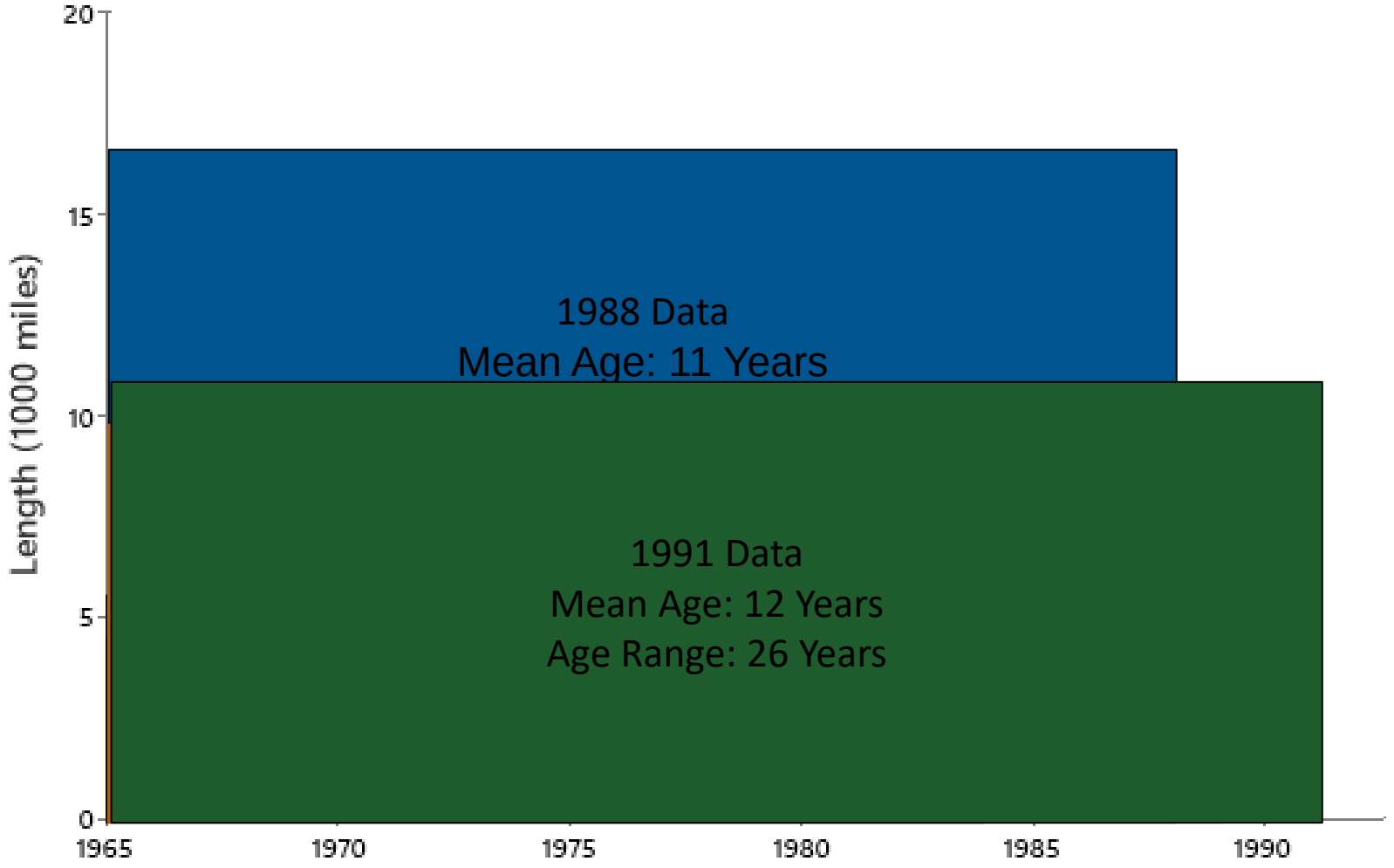
Not Significant

0.14
0.09
0.06

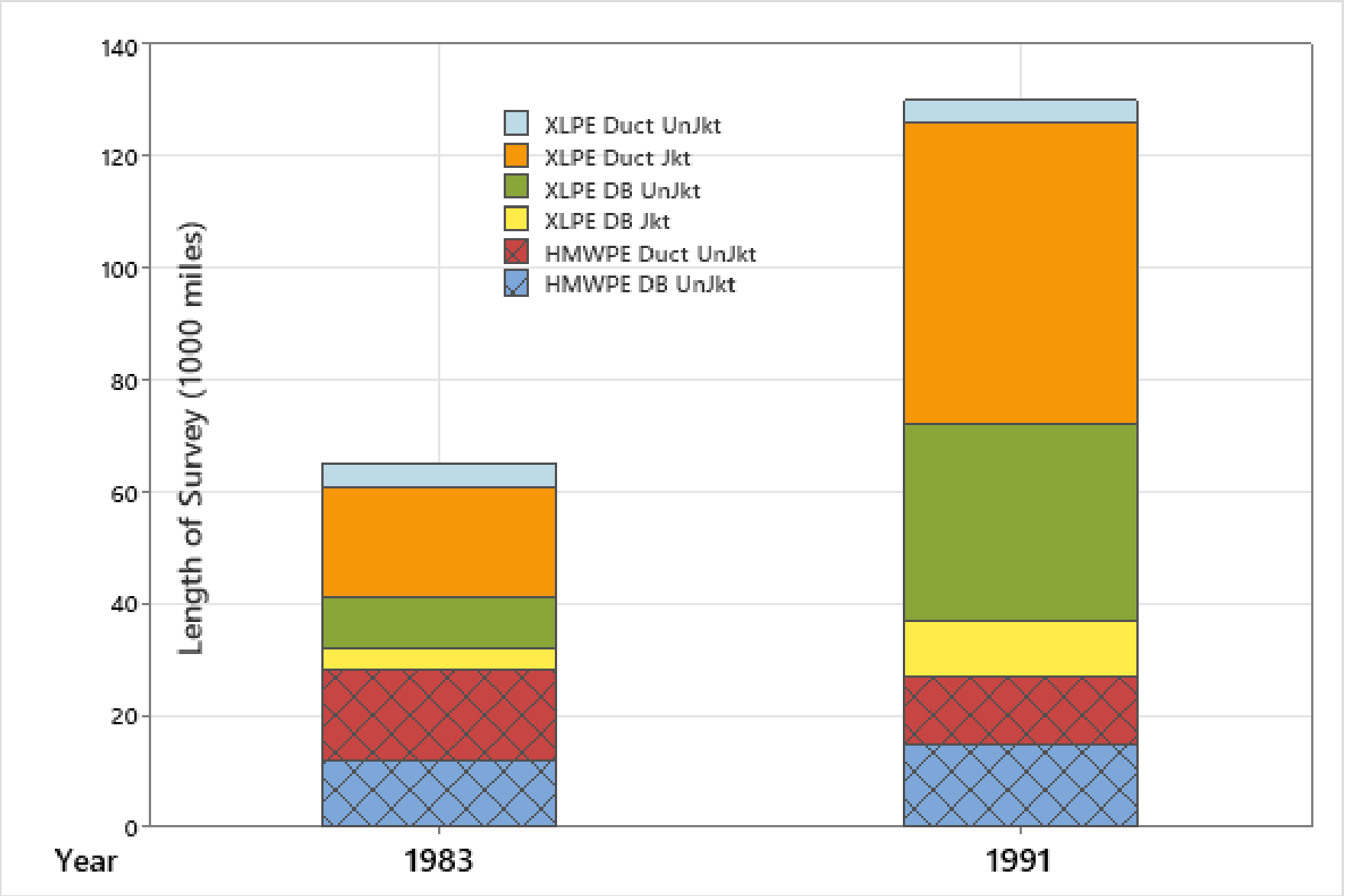
1.4
1
0.7

Significant

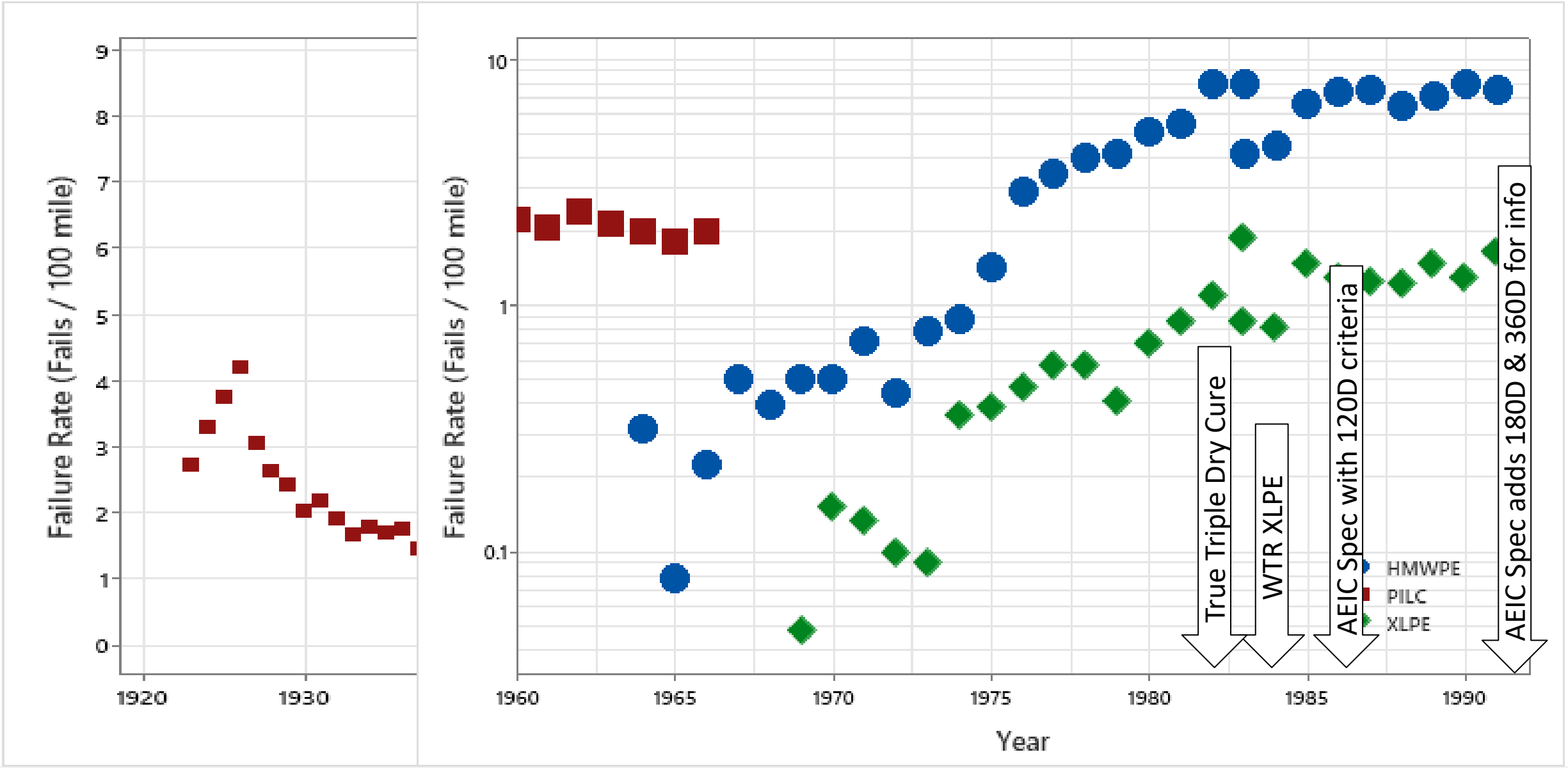
Contribution of Vintages to Failure Rates



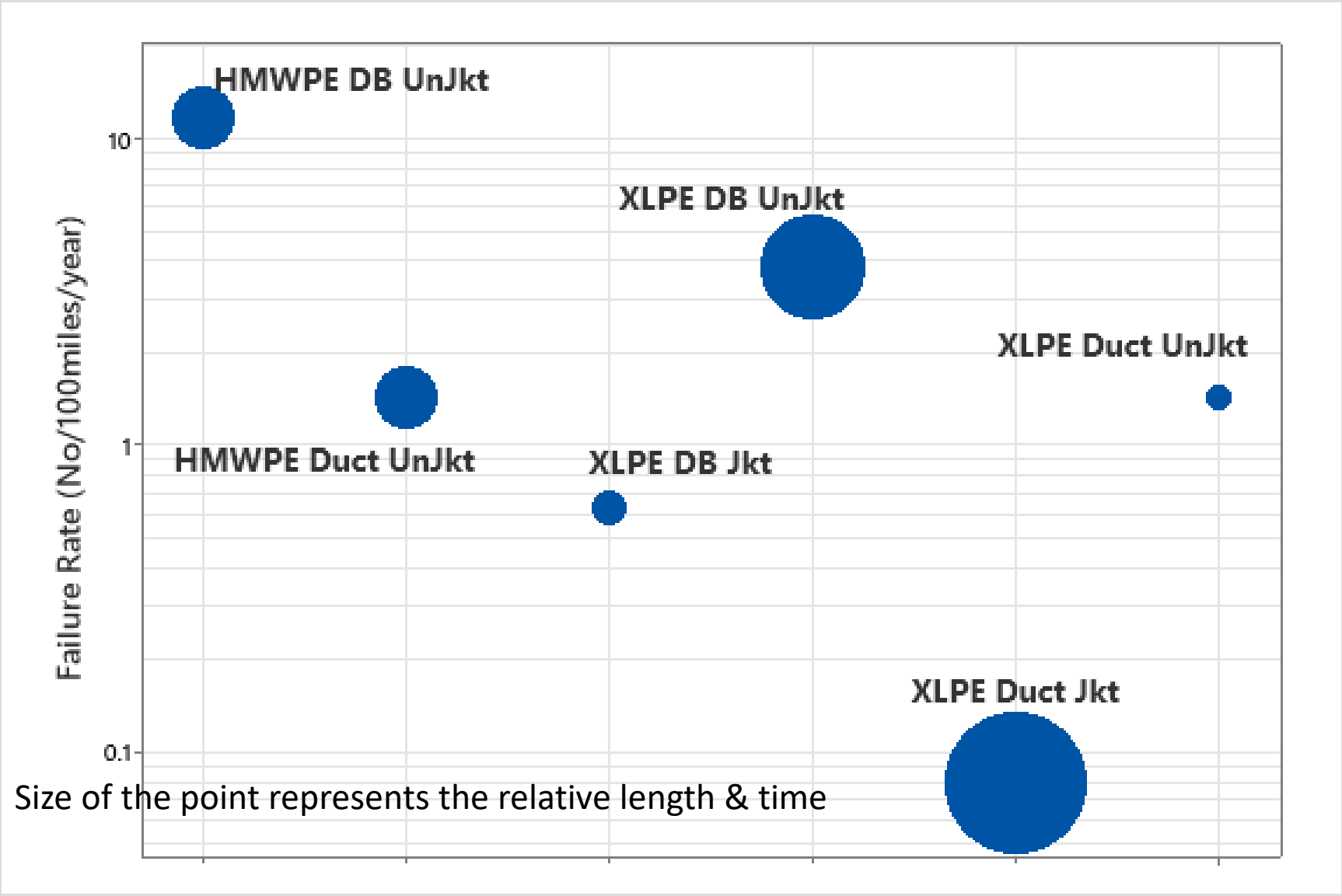
Lengths and Time changes



AEIC Data Added



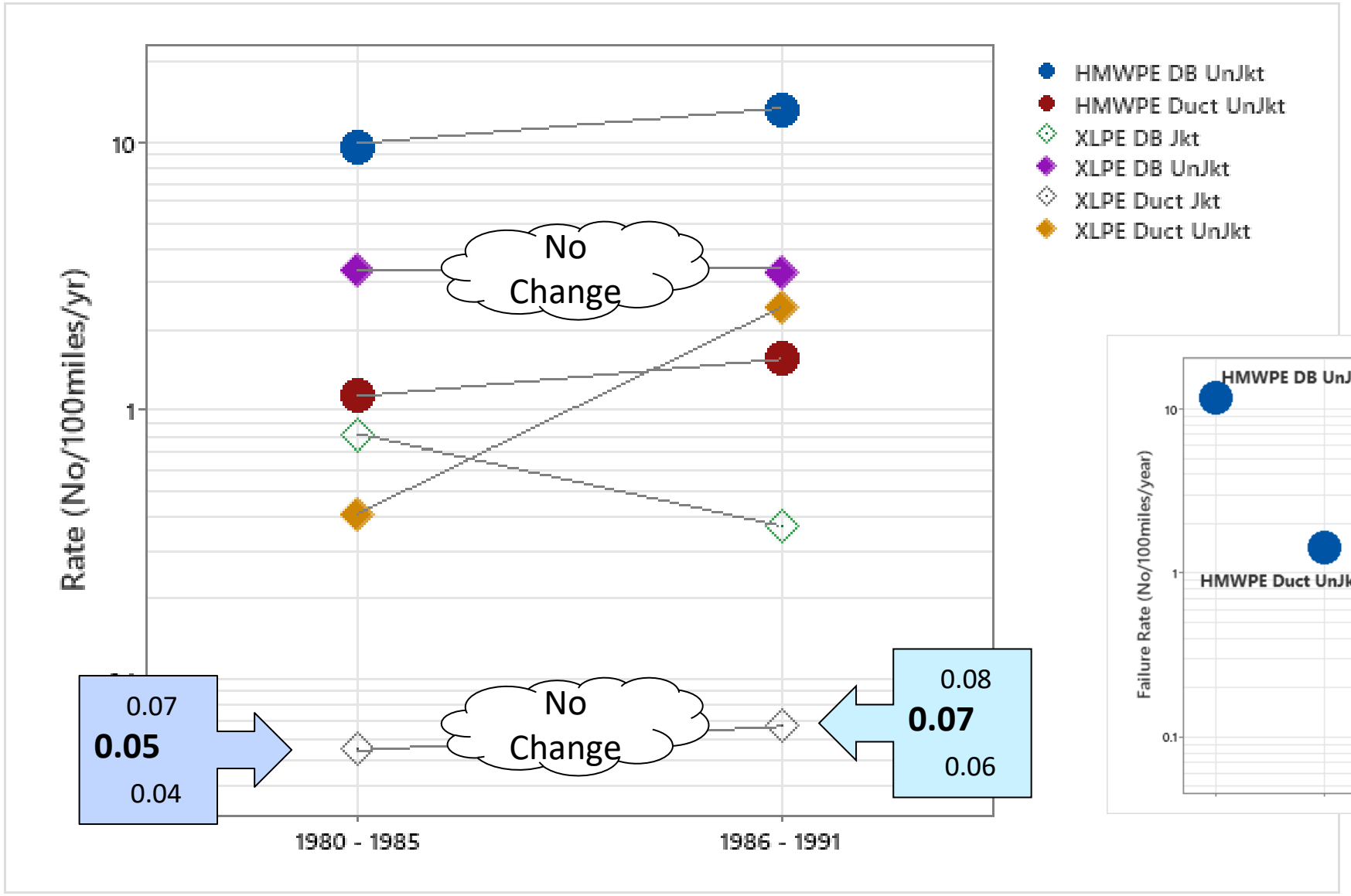
AEIC Industry Collated Data - segregated: 1983 to 1991

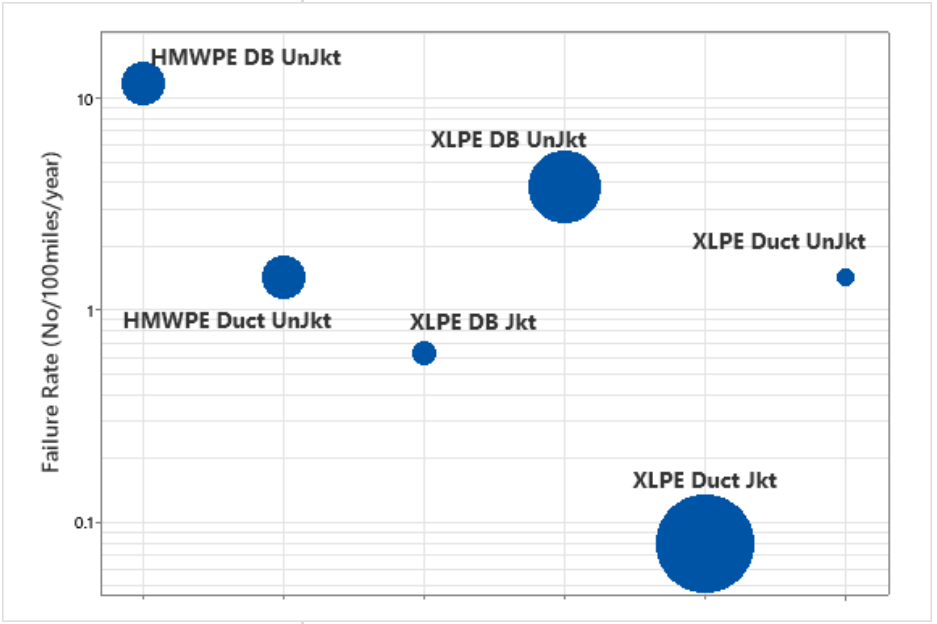


Importance of Cable Mix for Utility Rates

XLPE Direct Buried Jacketed: 0.7
XLPE Direct Buried Un Jacketed: 4
XLPE Duct Jacketed: 0.08
XLPE Duct Un Jacketed: 1.5
Failure Rate (#/100miles/yr)

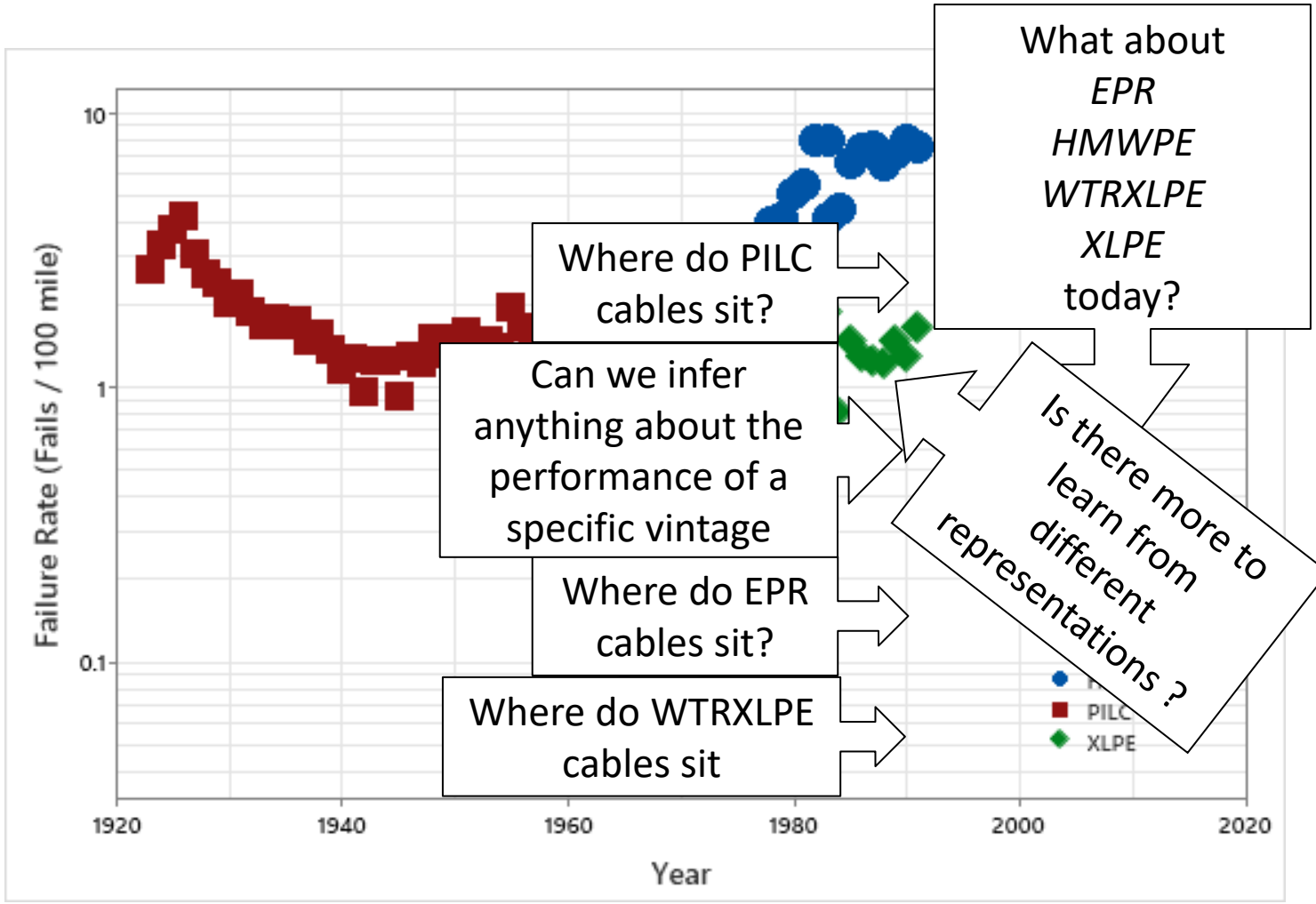
Changes with Time





To Wrap Up

- We still operate and rely on legacy systems (>35%), datamining can help us with the understanding of what might happen when we operate them differently
- There is useful knowledge within the ICC Minutes – *findability is important*
- There are still questions



- Nigel Hampton has more than 30 years of experience in the MV & HV cable field at BICC in the United Kingdom, Borealis in Sweden, NEETRAC, UL Solutions and currently EPRI in the United States. Nigel currently Chairs IEEE400.0 Field Testing Techniques and IEEE400.2 Field Testing using VLF Sources. Nigel has served as the Technical Advisor to the AEIC Cable Engineering Committee since 2008.