Creating Infinite Possibilities.

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Improving Operational Intelligence for Maintaining Cable Networks

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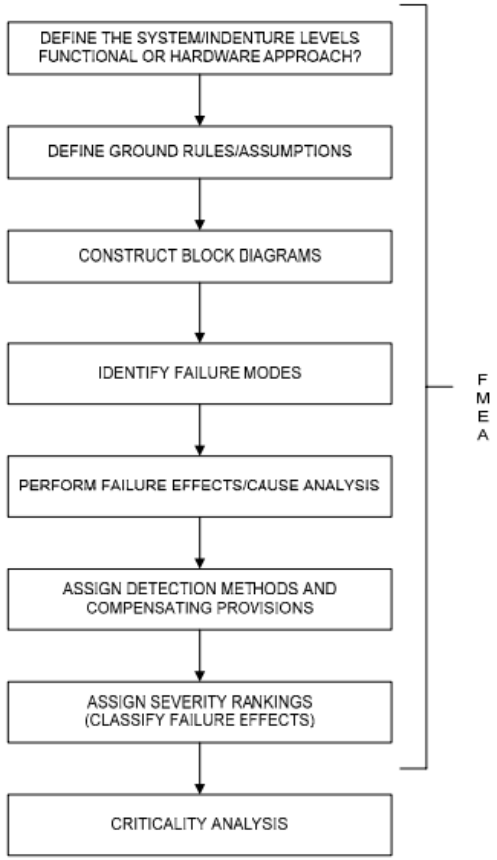
FMECA



Define the system boundaries – network, services, etc.

Define the use cases and missions of the system – be consistent

Define the subsystems and components

List the ways each component can fail – failure mode relates to indicator but is not the same thing

List the effects of each failure mode on the subsystems, system, use cases and missions – effects propagate through the system unless isolated immediately

Identify the criticality of each failure mode, usually a combination of probability, impact, and severity

Extend as needed for repair action, etc.

- Cause – ask “why” 5 times to find common causes for common management
- Repairability to assure fast repair, low-cost maintenance, etc.
- Support P&E, financial planning, etc.

Example - Tea Cup

System – teacup, not the saucer, not the tea, just the cup

Use cases – insulating beverage, prevent spilling, portable, access, delivery

Subsystems – holding tea: cup, lifting to mouth: handle

Component – handle, sides, bottom, rim, lid?

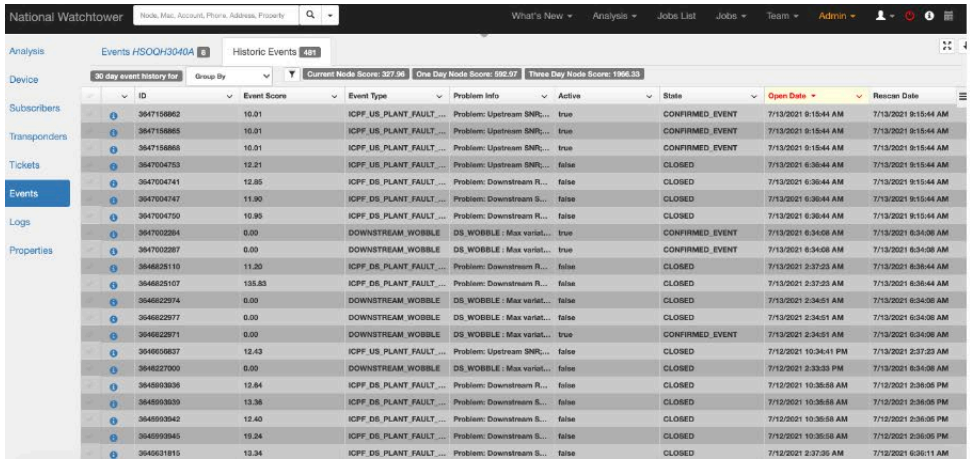
Failure modes – sides: cracked, warped, broken, discolored, dirty, scratched,

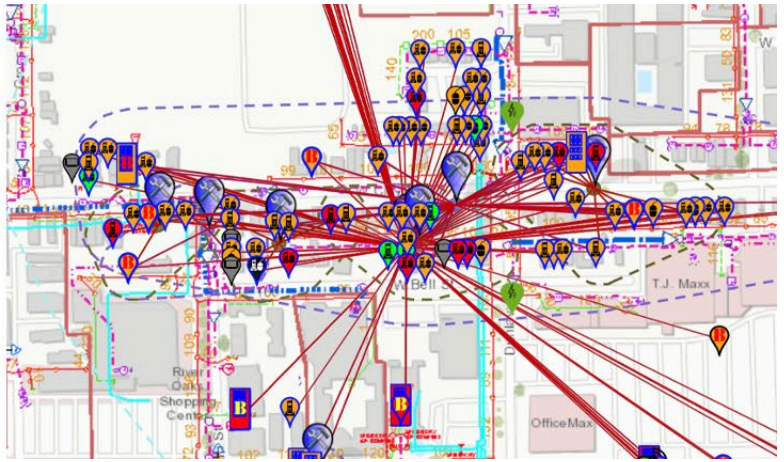
Effects – Break: liquid leaks, burns user, damages clothes, cut user, etc.

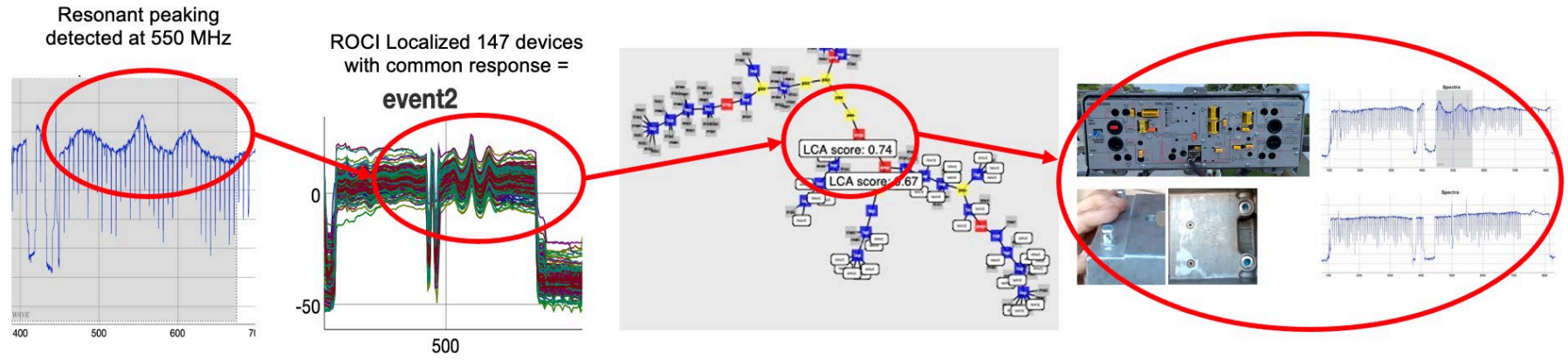
Criticality –

- Break: p = 0.001, n = 1, s = 0.9; c = 0.0009
- Break: p = high, n = single, s = high; c = very high

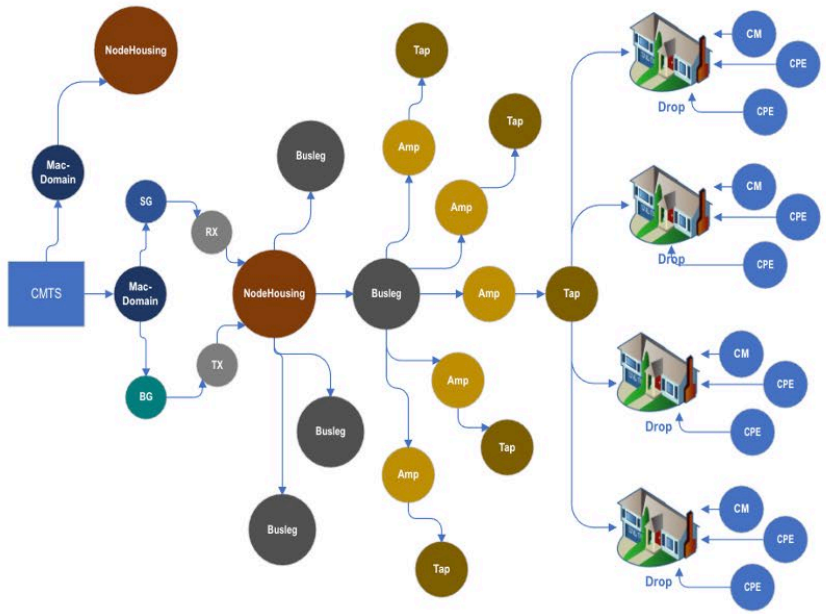
Event Management

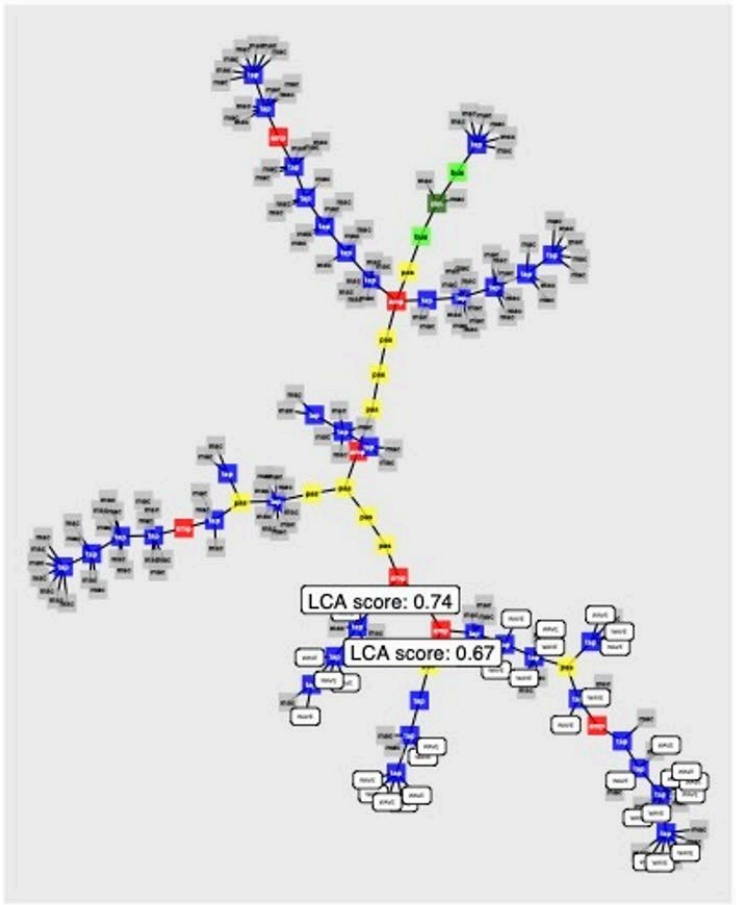






Network Graph – Localization, Analyze Impact





Failure mode narrows down localization.

Network graph and multiple data collection points further facilitates localization.

With the information available at this point, we analyze impact

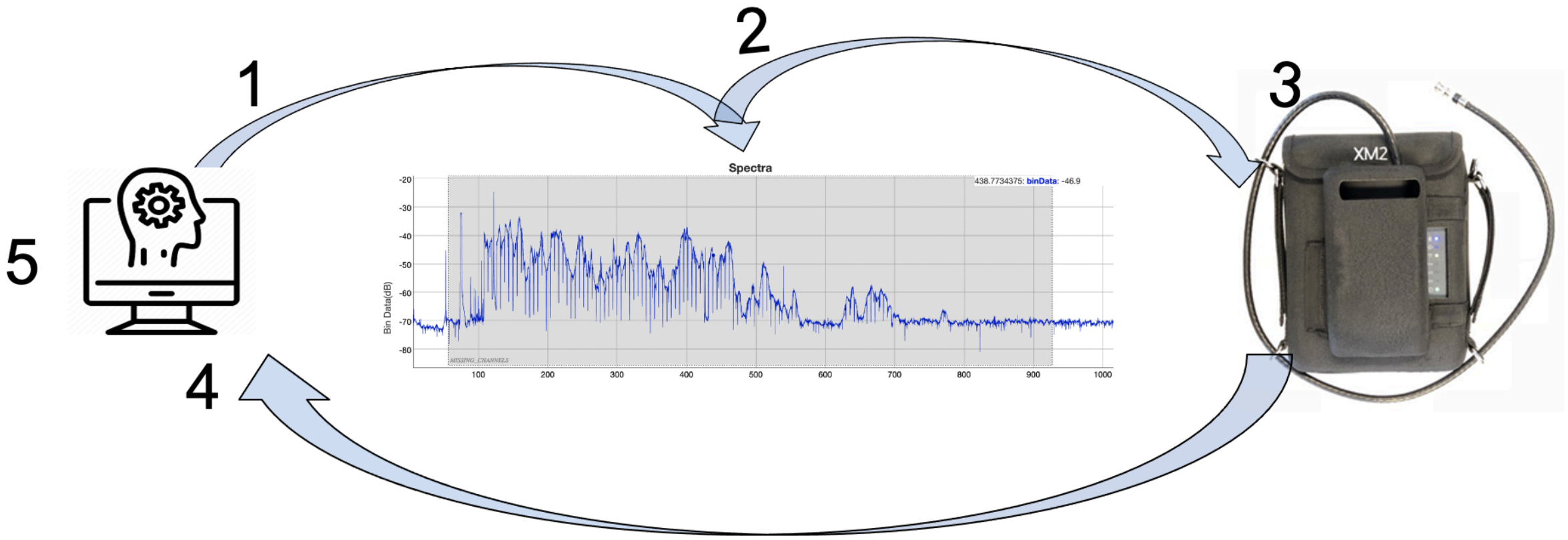
Criticality

Failure Subsystem	Failure Mode	Occurrence	Severity	Duration Days	Decay Rate	Decay Days	Criticality Model	Number of Subs
Home	Wiring	1	0.1	1	0.3	30	-20.00	1
Drop	Cut	1	1	1		60	40.00	1
Drop	Other Damage	1	0.3	0.5	0.025	180	-165.00	1
Drop	Water Damage	1	0.25	0.25	0.083	60	-53.75	1
Drop	Ingress - Customer	1	0.9	0.25		0	22.50	1
Drop	Ingress - Hot Drop	1	0.9	0.25		0	22.50	1
Tap	Damageed / Other	1	0.05	1		0	20.00	4
Tap	Damaged / Water	1	0.2	0.5		0	40.00	4
Feeder	Cut	1	1	1		0	1200.00	12
Feeder	Cracked	1	0.25	0.05		0	15.00	12
Feeder	Water Damage	1	0.6	0.3		0	216.00	12
Amplifier	Power Failure	1	1	1		0	2500.00	25
Amplifier	Grounding Fault	0.05	0.25	0.25		0	7.81	25
Amplifier	Failing Module	0.1	1	0.1		0	25.00	25
Hardline	Cut	1	1	1		0	5000.00	50
Hardline	Damaged	0.2	0.25	0.2		0	50.00	50
Hardline	Shielding Separation	1	0.25	1		0	1250.00	50
Sm Node	Power Failure	1	1	1		0	15000.00	150
Med Node	Power Failure	1	1	1		0	30000.00	300
Large Node	Power Failure	1	1	1		0	60000.00	600
Headend	ACP (Channel Alignment)	1	0.025	1		0	12500.00	5000

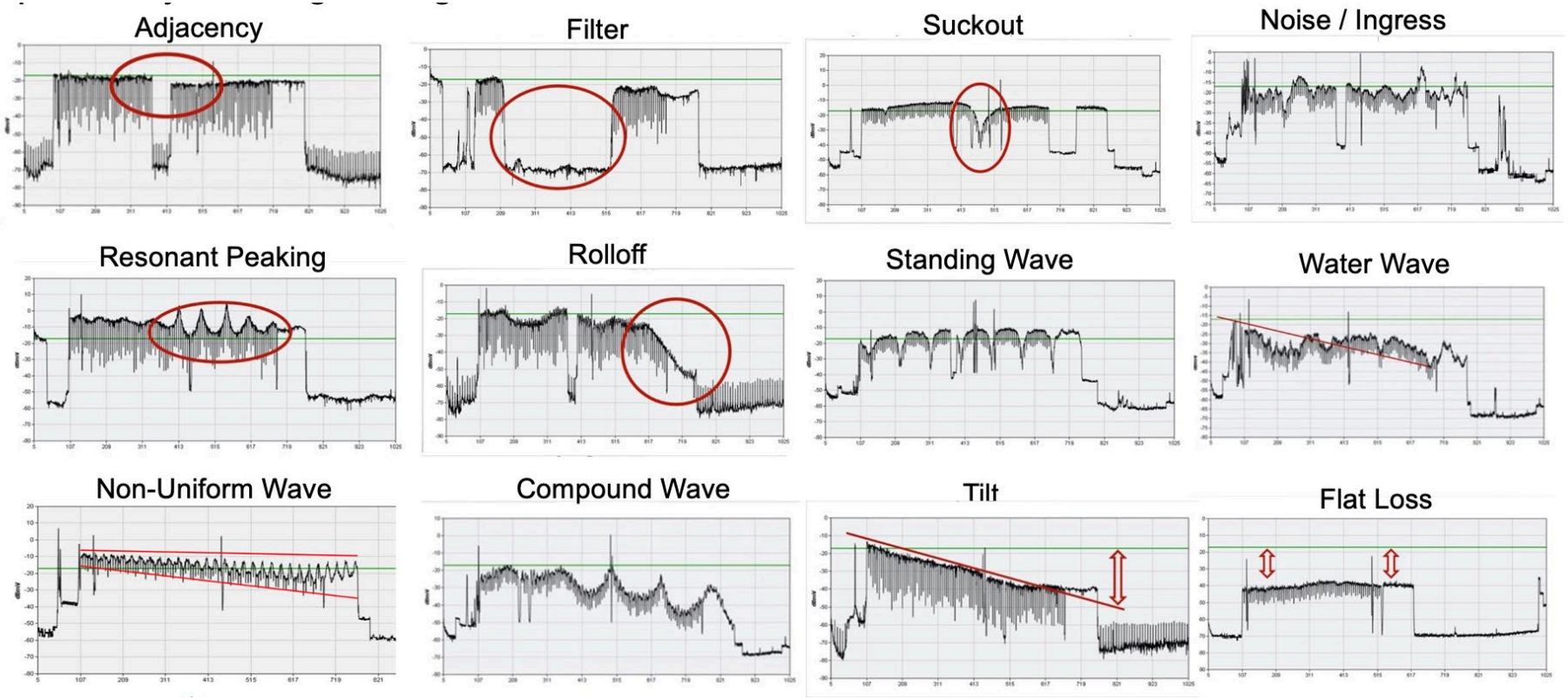
Benefit of Reliability

Probabilty of Repair	Repair Disruption Mins	Benefit of Cost (BCR)	Benefits of TCs	Benefit of Churn	Benefit of Reliability
0.30	60.00	-0.09	-0.20	-0.01	-20.00
1.00	0.01	0.19	0.40	0.01	40.00
0.90	0.05	-0.74	-1.65	-0.04	-165.00
0.70	0.05	-0.22	-0.54	0.00	-53.75
0.70	0.05	0.09	0.23	0.00	22.50
0.70	0.05	0.09	0.23	0.01	22.50
0.95	0.05	0.29	0.80	0.02	80.00
0.75	0.25	0.27	1.60	0.04	160.00
1.00	0.01	22.15	144.00	3.60	14400.00
1.00	0.01	0.24	1.80	0.05	180.00
1.00	0.01	3.46	25.92	0.65	2592.00
0.50	0.01	83.33	625.00	15.63	62500.00
0.50	0.01	0.26	1.95	0.05	195.31
0.50	0.01	0.83	6.25	0.16	625.00
1.00	0.01	277.78	2500.00	62.50	250000.00
0.70	0.01	2.31	25.00	0.63	2500.00
0.70	0.01	57.87	625.00	15.63	62500.00
0.70	0.01	2083.33	22500.00	562.50	2250000.00
0.70	0.01	8333.33	90000.00	2250.00	9000000.00
0.70	0.01	33333.33	360000.00	9000.00	36000000.00
0.70	0.01	181159.42	625000.00	15625.00	62500000.00

Closed loop – Detection, Decision, Repair



Spectrum Impairments



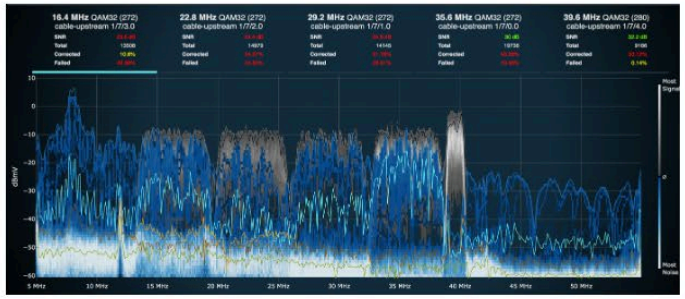
Spectrum impairments link to faults, which link to network failure modes

Each failure mode links to localization and severity, but also the repair action to take

Upstream Spectrum too

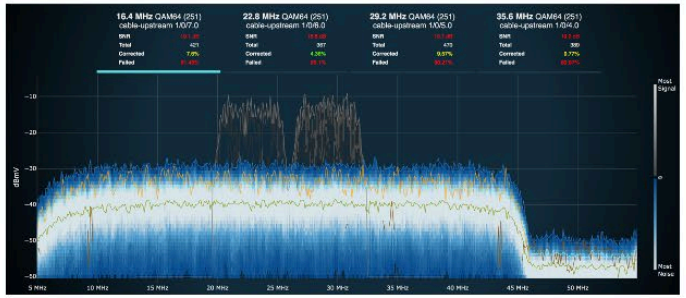
Upstream spectrum completes the impairment set.

Burst Noise

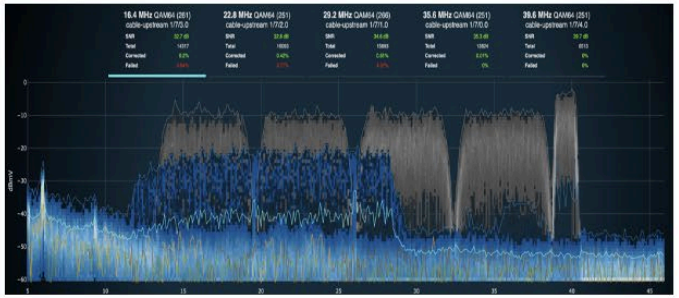


Clipping

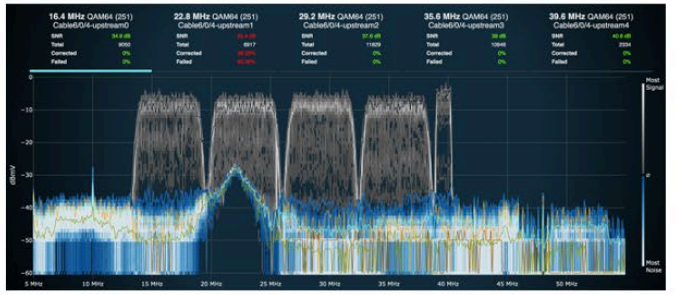
CPD



HPNA



XB3 / CMD

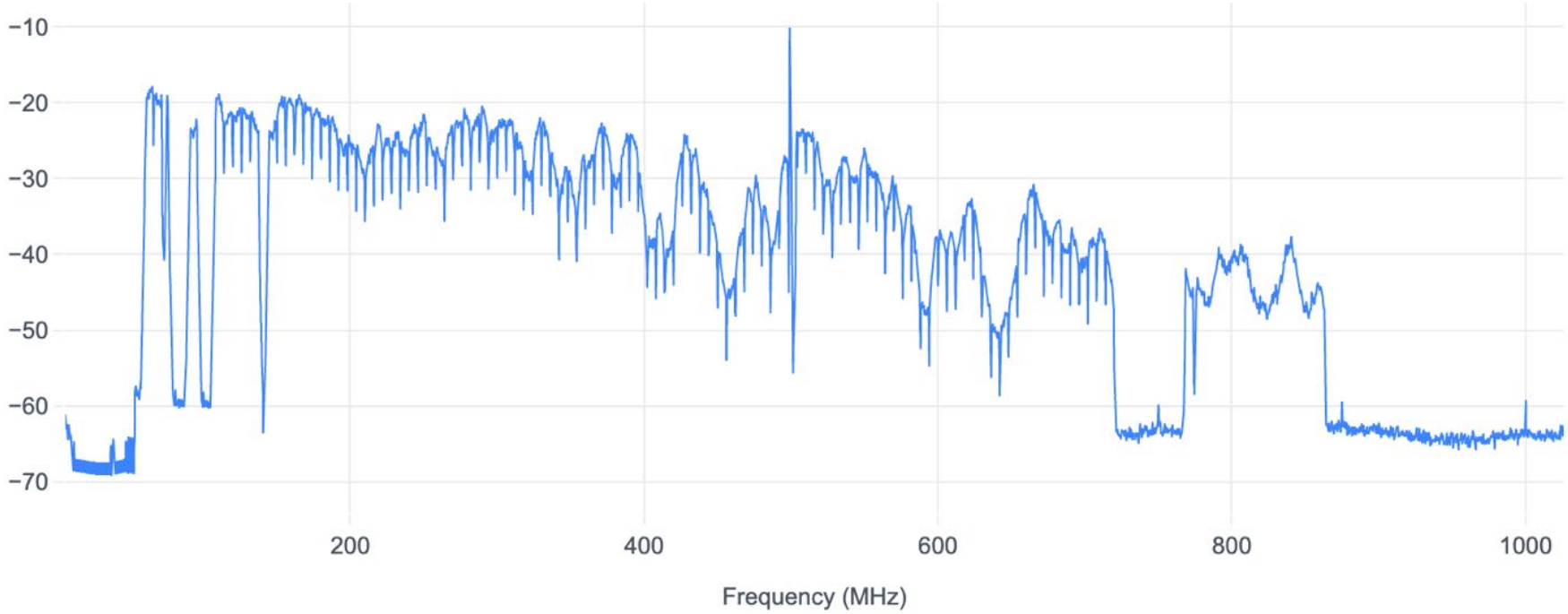


Water ’bout water?

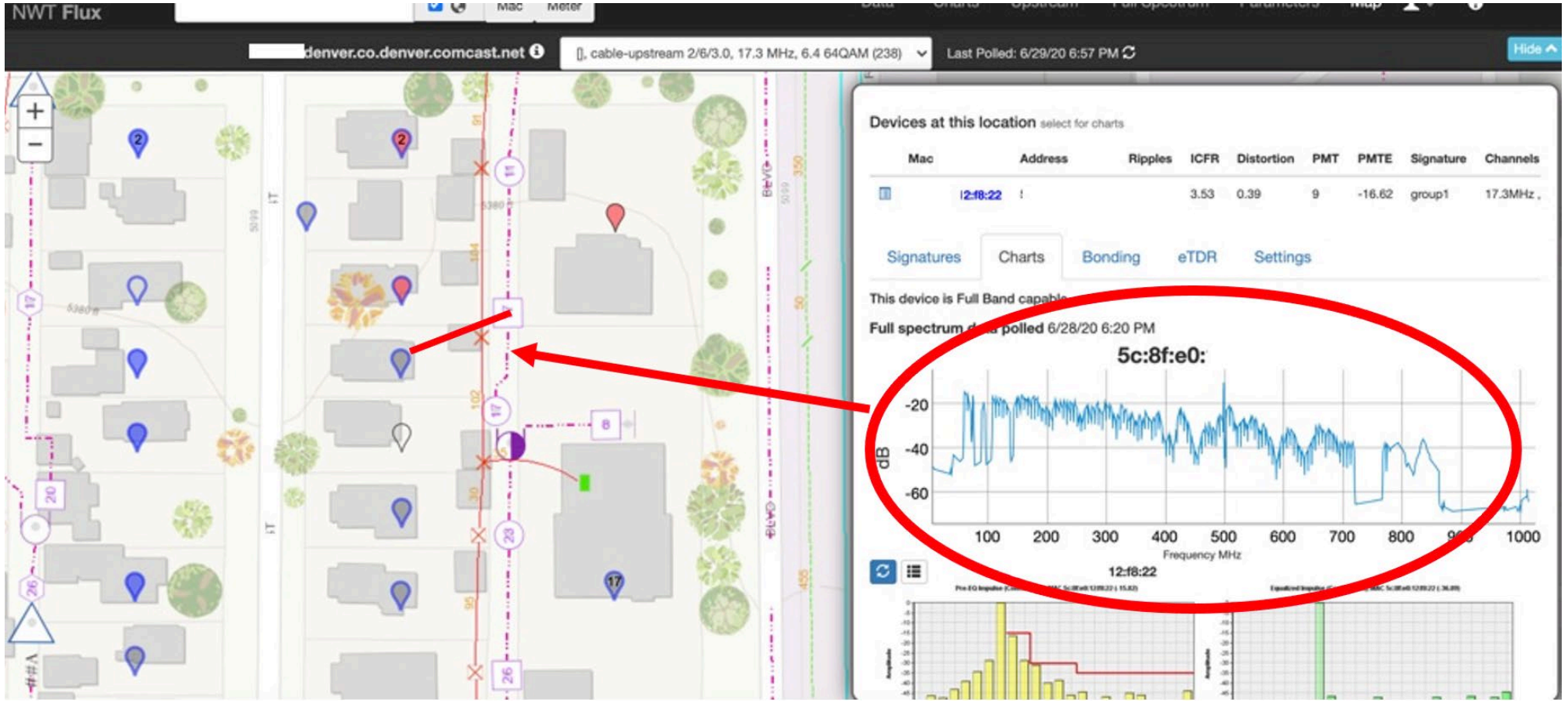
Water in cable has a distinctive signature

Aperiodic variability in spectrum dB

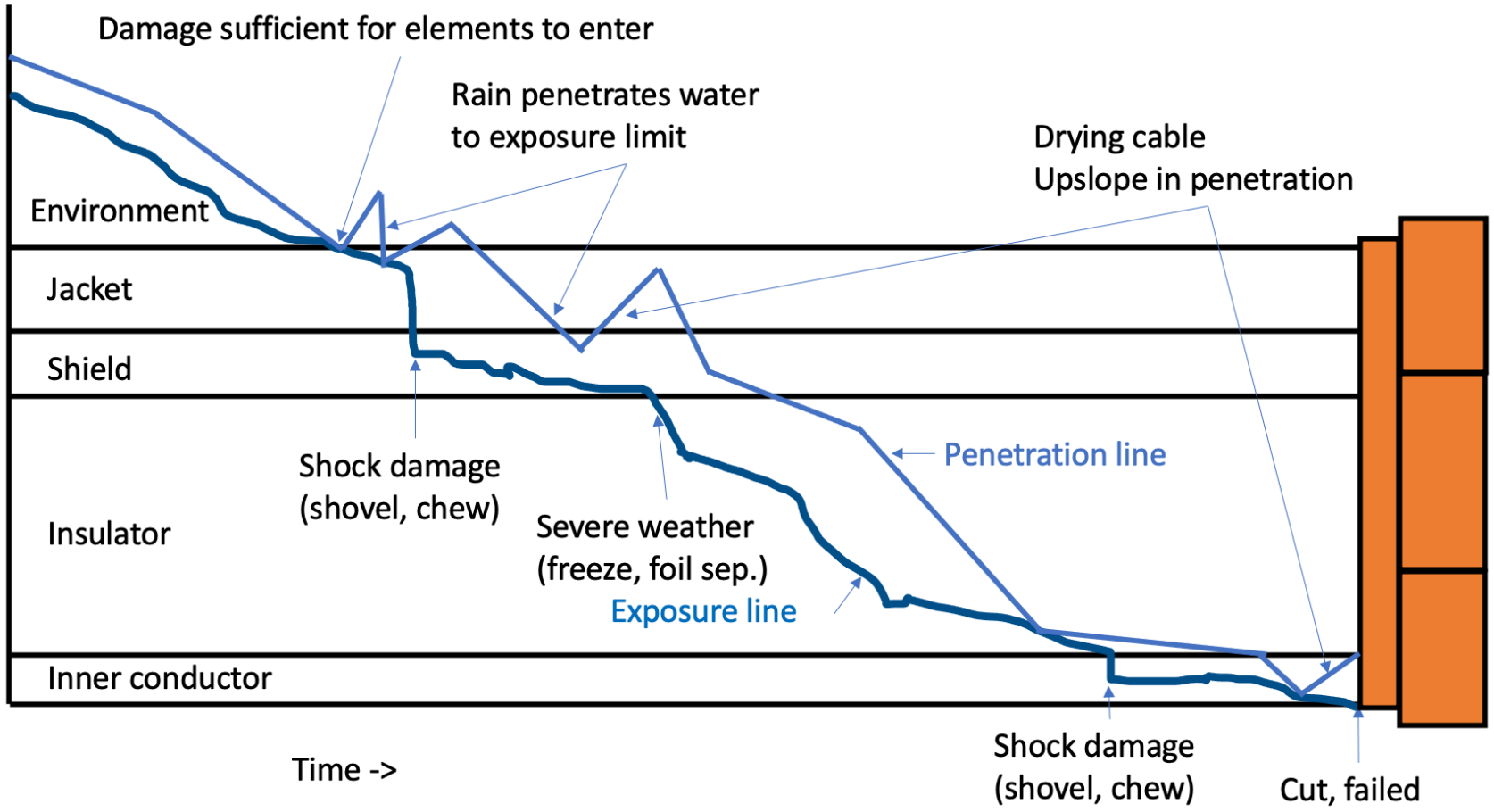
Lower power at higher frequencies



Water localization



The observable cable degradation story



- Cable jacket and shield damaged by water and environment, or shock damage events
- Eventually, water and elements get into the cable through damage points, and cause more damage
- RF signals are eventually impaired
- Left untreated, eventual failure occurs

Find wet cable and remove

Capture spectrum

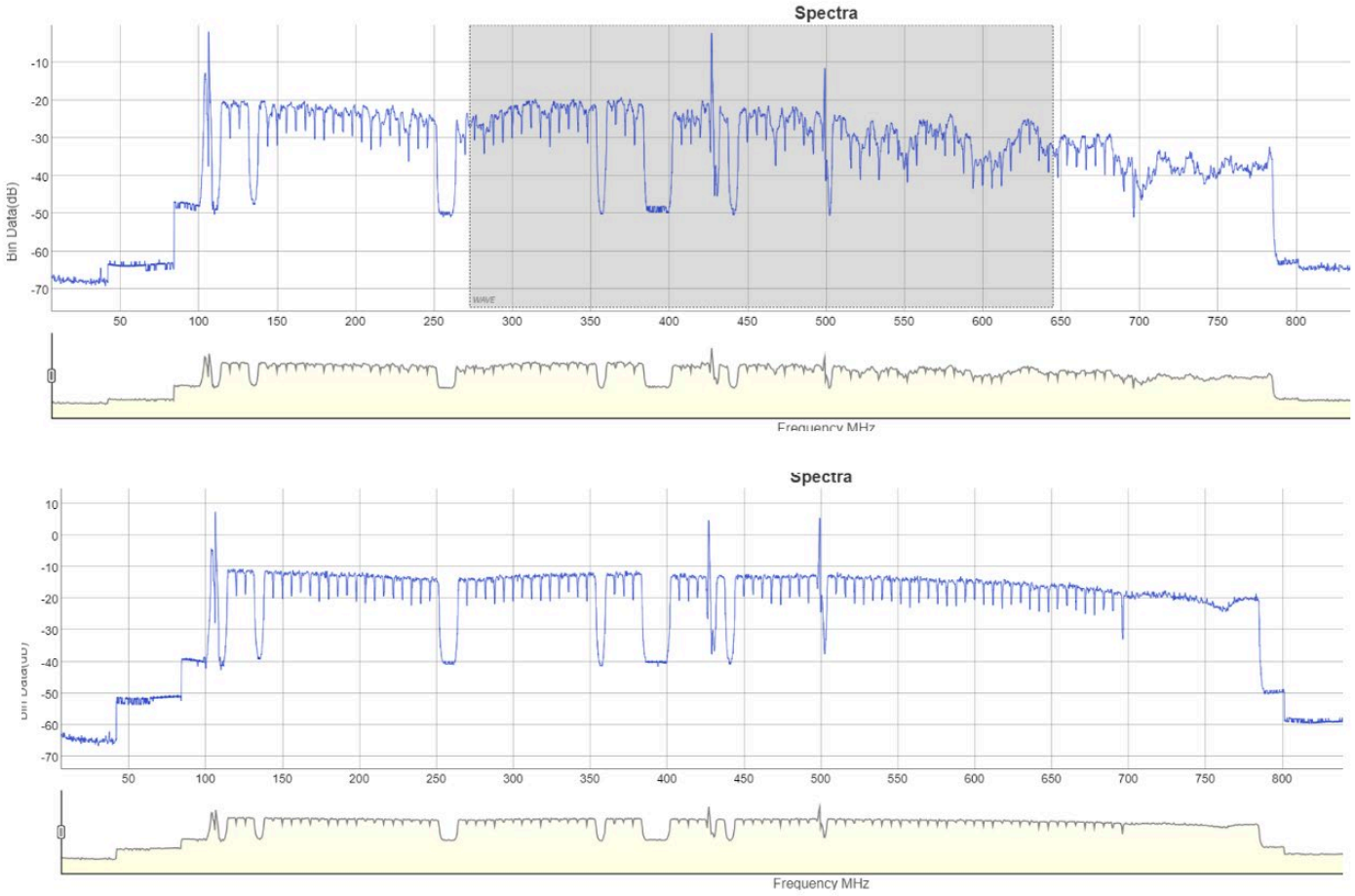
Identify patterns automatically

Localize fault

Find and remove failed wet cable

Delight customers efficiently

Drop the mic and high five!



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Thank You!

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