

# Creating Infinite Possibilities.

# Improving Operational Intelligence for Maintaining Cable Networks

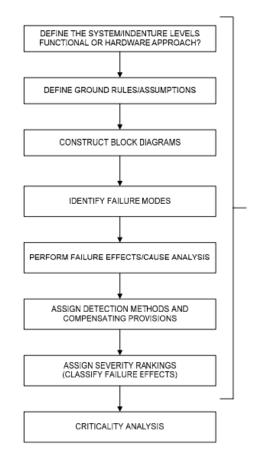
#### **Mike Spaulding**

Vice President, Plant Maintenance Comcast Corporation Michael\_Spaulding@cable.comcast.com 303-917-4003





### **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.

м Е А



# 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 -

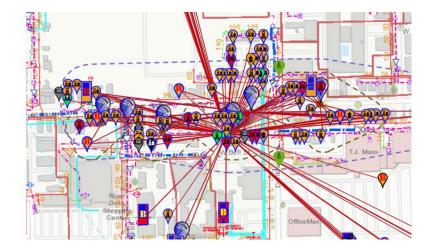
- Break: p = 0.001, n = 1, s = 0.9; c = 0.0009
- Break: p = high, n = single, s = high; c = very high

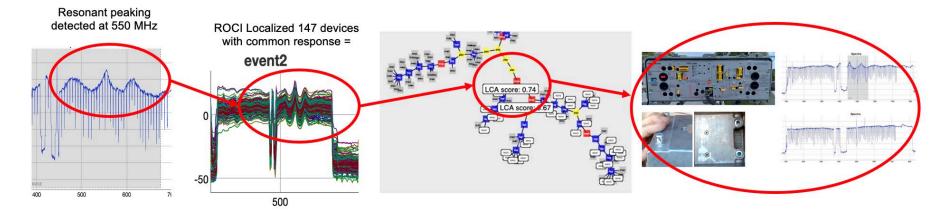




#### Event Management

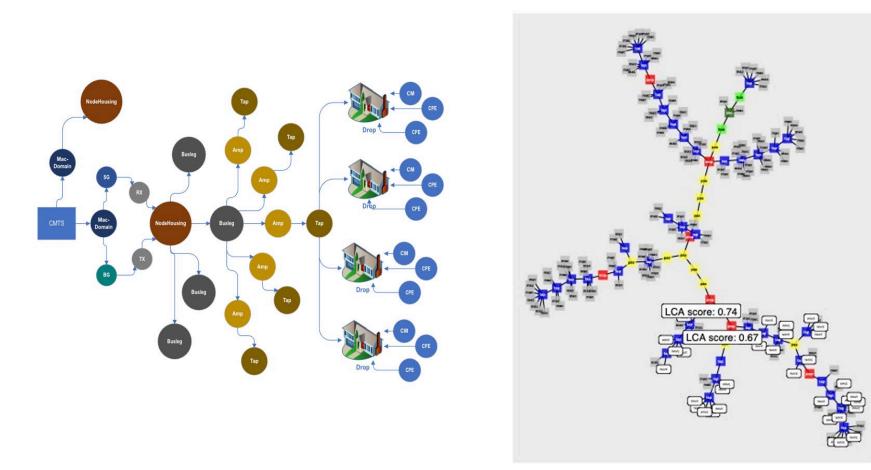
nalysis	Events	HSOQH3040A	Historic Events 481						2	1
evice	30 day ev	ant history for Group By	V Y Current N	ode Score: 327.96 📔 One Day	Node Score: 592.97 Three	Day Node Score: 1956.33				
		ID v	Event Score v	Event Type 🗸 🗸	Problem info 🔍 🗸	Active 🗸	State ~	Open Date 🔹 🗸 🗸	Rescan Date	
ubscribers	0	3647156862	10.01	ICPF_US_PLANT_FAULT	Problem: Upstream SNR;	true	CONFIRMED_EVENT	7/13/2021 9:15:44 AM	7/13/2021 9:15:44 AM	
Transponders	0	3647156865	10.01	ICPF_US_PLANT_FAULT	Problem: Upstream SNR;	true	CONFIRMED_EVENT	7/13/2021 9:15:44 AM	7/13/2021 9:15:44 AM	
	0	3647156868	10.01	ICPF_US_PLANT_FAULT	Problem: Upstream SNR;	true	CONFIRMED_EVENT	7/13/2021 9:15:44 AM	7/13/2021 9:15:44 AM	
ckets	0	3647004753	12.21	ICPF_US_PLANT_FAULT	Problem: Upstream SNR;	faine	CLOSED	7/13/2021 6:36:44 AM	7/13/2021 9:15:44 AM	
1000	0	3547004741	12.85	ICPF_DS_PLANT_FAULT	Problem: Downstream R	faise	CLOSED	7/13/2021 6:36:44 AM	7/13/2021 9:15:44 AM	
vents	0	3547004747	11.90	ICPF_DS_PLANT_FAULT	Problem: Downstream S	faise	CLOSED	7/13/2021 6:36:44 AM	7/13/2021 9:15:44 AM	
xqs	0	3647004750	10.95	ICPF_DS_PLANT_FAULT	Problem: Downstream R	faise	CLOSED	7/13/2021 6:36:44 AM	7/13/2021 9:15:44 AM	
,g.,	0	3647002264	0.00	DOWNSTREAM_WOBBLE	DS_WOBBLE : Max variat	true	CONFIRMED_EVENT	7/13/2021 6:34:08 AM	7/13/2021 0:34:08 AM	
operties	0	3647002287	0.00	DOWNSTREAM_WOBBLE	DS_WOBBLE : Max variat	true	CONFIRMED_EVENT	7/13/2021 6:34:08 AM	7/13/2021 6:34:08 AM	
	0	3646825110	11.20	ICPF_DS_PLANT_FAULT	Problem: Downstream R	faise	CLOSED	7/13/2021 2:37:23 AM	7/13/2021 8:38:44 AM	
	0	3646825107	135.83	ICPF_DS_PLANT_FAULT	Problem: Downstmem R	falae	CLOSED	7/13/2021 2:37:23 AM	7/13/2021 6:36:44 AM	
	8	3646822974	0.00	DOWNSTREAM_WOBBLE	DS_WOBBLE : Max variat	faise	CLOSED	7/13/2021 2:34:51 AM	7/13/2021 6:34:08 AM	
	0	3646822977	0.00	DOWNSTREAM_WOBBLE	DS_WOBBLE : Max variat	faise	CLOSED	7/13/2021 2:34:51 AM	7/13/2021 6:34:08 AM	
	6	3646622971	0.00	DOWNSTREAM_WOBBLE	DS_WOBBLE : Max variat	true	CONFIRMED_EVENT	7/13/2021 2:34:51 AM	7/13/2021 6:34:06 AM	
	0	3646656837	12.43	ICPF_US_PLANT_FAULT	Problem: Upstream SNR;	faise	CLOSED	7/12/2021 10:34:41 PM	7/13/2021 2:37:23 AM	
	0	3646227000	0.00	DOWNSTREAM_WOBBLE	DS_WOBBLE : Max variat	false	CLOSED	7/12/2021 2:33:33 PM	7/13/2021 6:34:08 AM	
	0	3645903936	12.64	ICPF_DS_PLANT_FAULT	Problem: Downstream R	faise	CLOSED	7/12/2021 10:35:58 AM	7/12/2021 2:36:05 PM	
	0	3645903939	13.36	ICPF_DS_PLANT_FAULT	Problem: Downstream S	false	CLOSED	7/12/2021 10:35:58 AM	7/12/2021 2:36:05 PM	
	0	3645993942	12.40	ICPF_DS_PLANT_FAULT	Problem: Downstream S	faise	CLOSED	7/12/2021 10:35:58 AM	7/12/2021 2:36:05 PM	
		3645993945	19.24	ICPF_DS_PLANT_FAULT	Problem: Downstream S	faise	CLOSED	7/12/2021 10:35:58 AM	7/12/2021 2:36:05 PM	
		3645631815	13,34	ICPF DS PLANT FAULT	Problem: Downstream S	taise	CLOSED	7/12/2021 2:37:35 AM	7/12/2021 6:36:11 AM	







#### Network Graph – Localization, Analyze Impact



Failure mode narrows down localization.

Network graph and multiple data collection points further facilitates localization.

clamshellRx busleg

passive

device

physical

type

With the information available at this point, we analyze impact



# Criticality

Failure Subsystem	Failure Mode	Occurrence	Severity	<b>Duration Days</b>	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
Тар	Damageed / Other	1	0.05	1		0	20.00	4
Тар	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

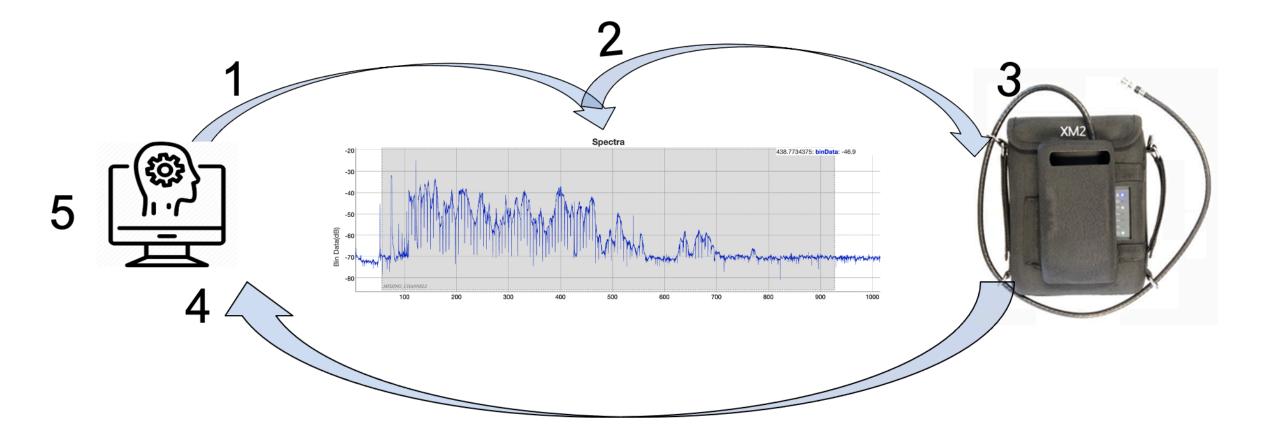


#### Benefit of Reliability

<b>Probabilty of Repair</b>	<b>Repair Disruption Mins</b>	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	900000.00
0.70	0.01	33333.33	360000.00	9000.00	3600000.00
0.70	0.01	181159.42	625000.00	15625.00	62500000.00

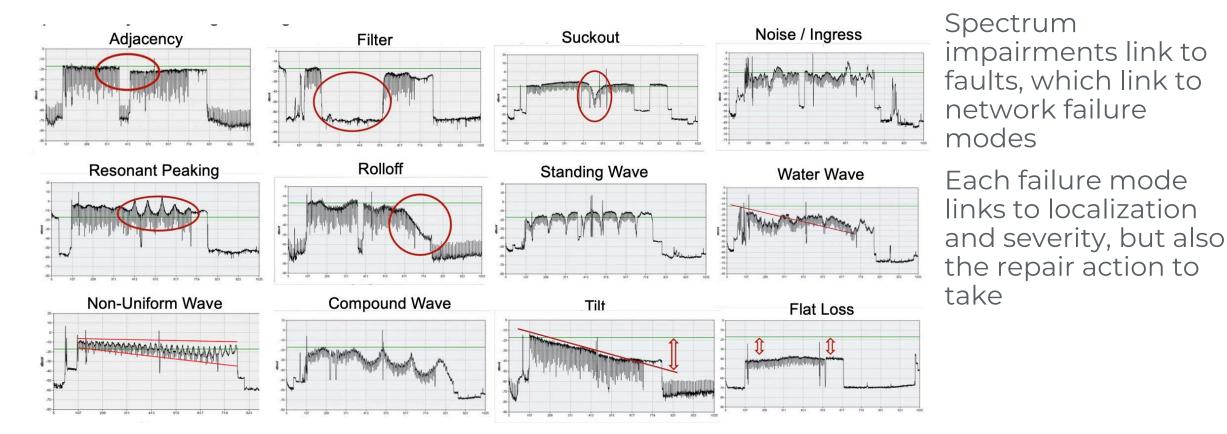


# Closed loop – Detection, Decision, Repair





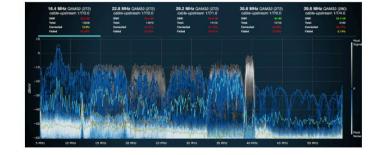
### Spectrum Impairments





### Upstream Spectrum too

Upstream spectrum completes the impairment set.



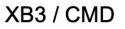
**Burst Noise** 

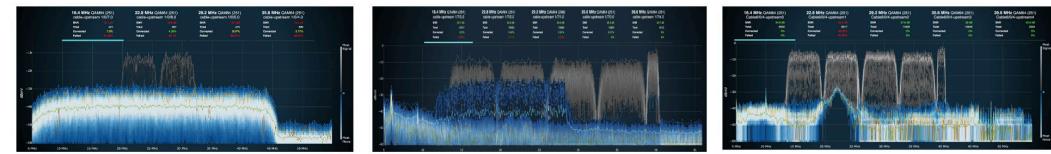


Clipping

CPD



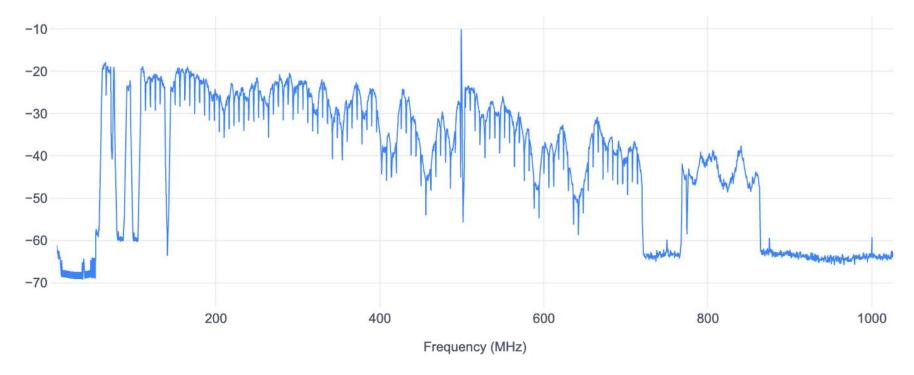






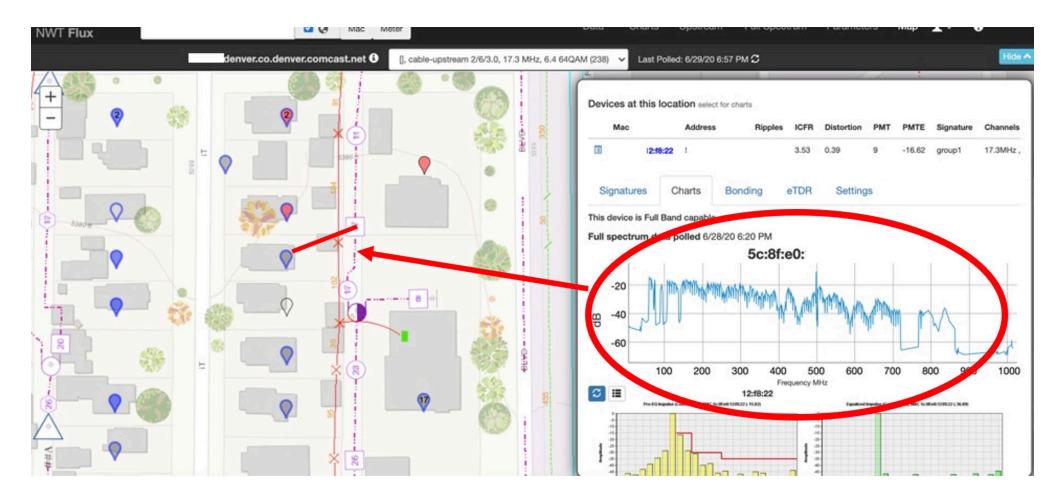
### Water 'bout water?

Water in cable has a distinctive signature Aperiodic variability in spectrum dB Lower power at higher frequencies



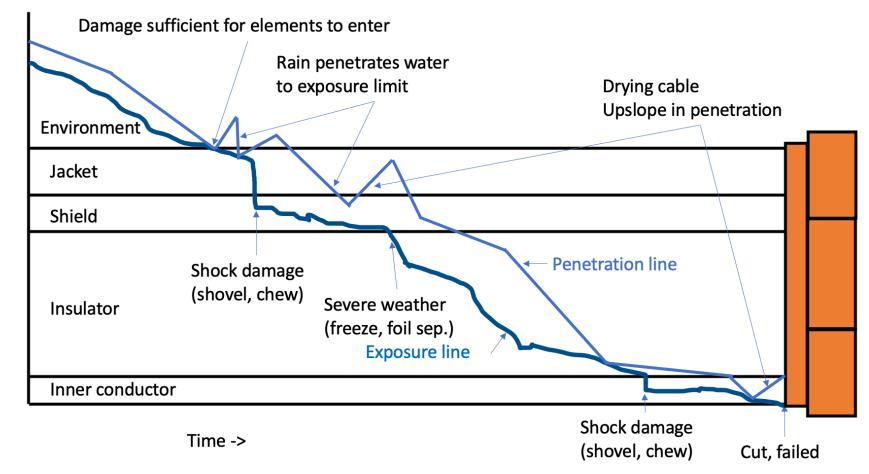


### Water localization





### 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

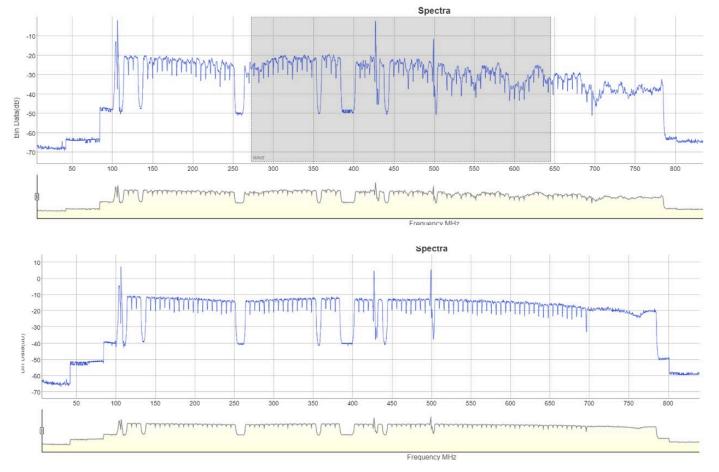
Capture spectrum

Identify patterns automatically Localize fault

Find and remove failed wet cable

Delight customers efficiently

Drop the mic and high five!





# Creating Infinite Possibilities.

# Thank You!

Mike Spaulding

Vice President, Plant Maintenance Comcast Corporation Michael\_Spaulding@cable.comcast.com 303-917-4003

