Real Time Monitoring of RF System Performance

Presented By: Dan Glavin

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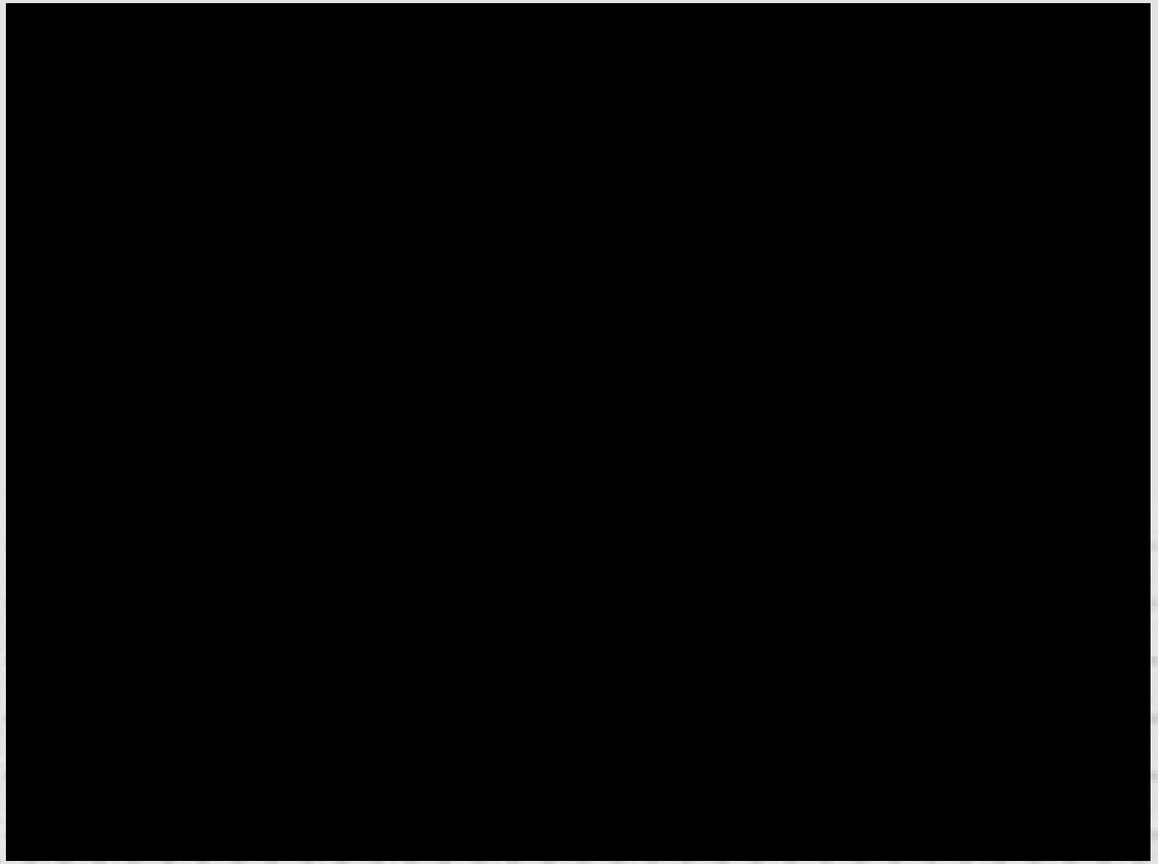
AGENDA

- Live Monitoring: Why it is Necessary
- Minor Field Issues
- Collateral Damage
- Current Practices
- Next Generation Approach
- Results

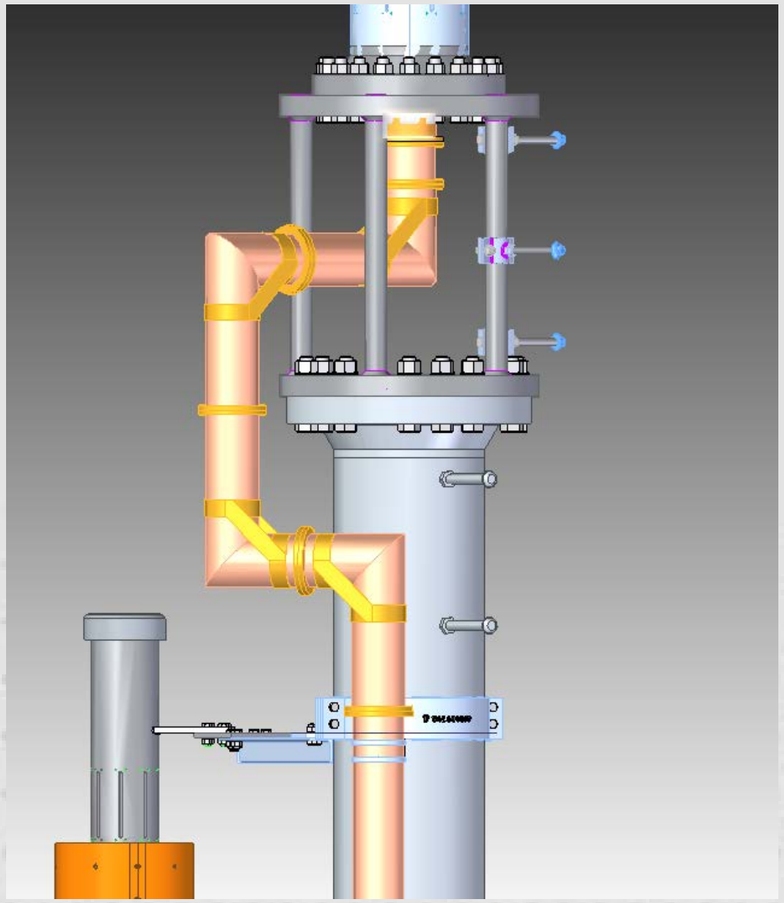
Live Monitoring: Why it is Necessary



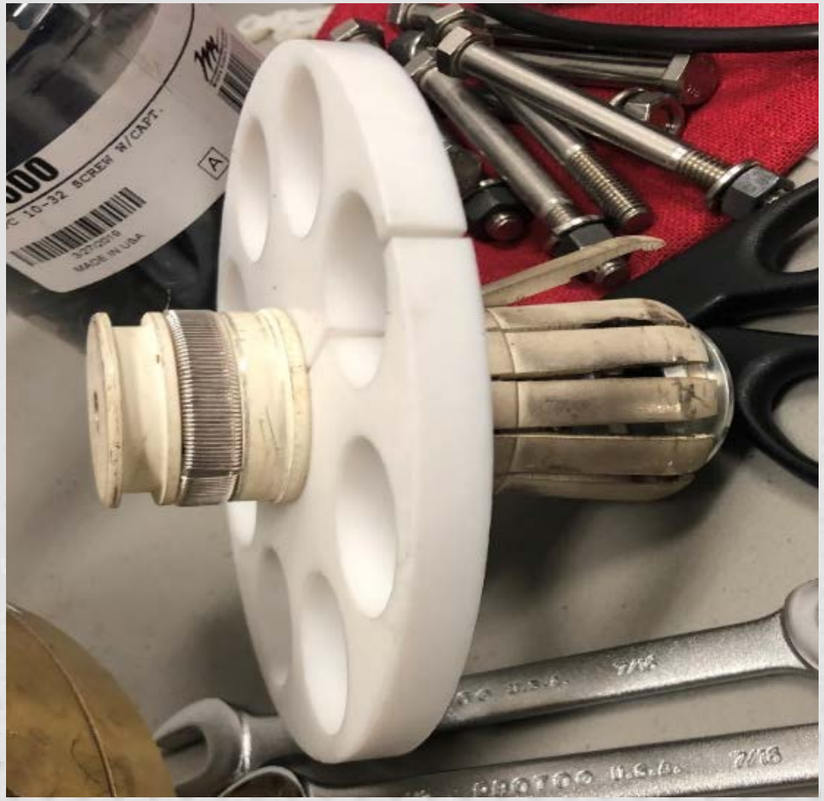
Video Credit to YouTube User apsparky

Live Monitoring: Why it is Necessary

- Transmission line is a vital component to delivering adequate power to a broadcast system
- Components and joints can become susceptible to failures over time
- Each component is handled by several people beginning with manufacturing and ending with installation



Minor Field Issues



Minor Field Issues

- Damaged in transit or installation
- Discontinuity in contact ring creates an area for series arcing
- Series arcing eats away at the brass
- Impedance mismatch increases as metal deteriorates
- Outer-to-outer series arcing evolves into inner-to-outer arcing
- End result = Failure

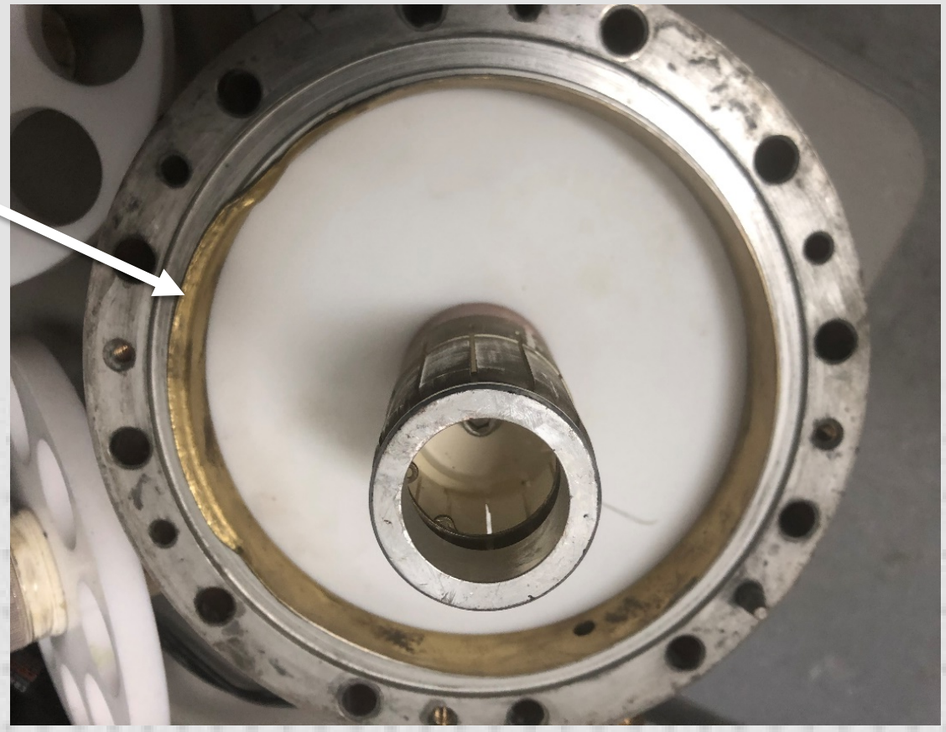


Figure 1: Damaged contact surface

Minor Field Issues

- Components such as O Rings and Teflon insulators can easily be pinched between flanges
- Introduce dielectric between contact surfaces
- Fosters environment for series arcing between outer conductors
- May not be seen on commissioning system sweep

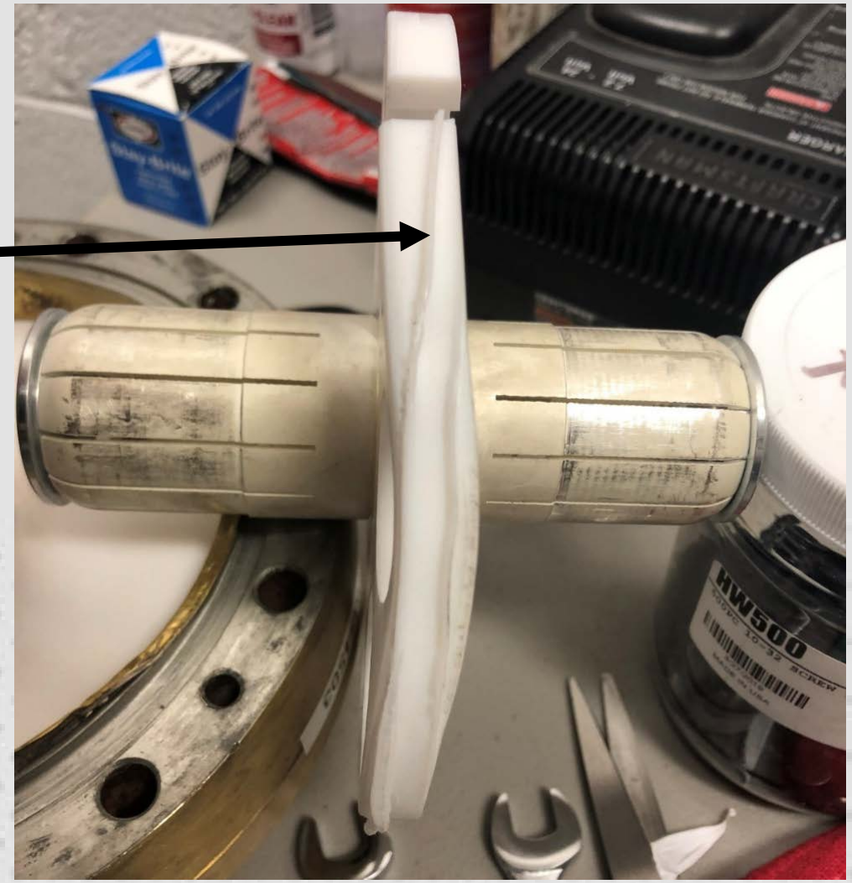


Figure 2: Insulator Crushed Between Transmission Line Flanges

Minor Field Issues

- Carbon will build up over time
- Excessive build up will lead to melting Teflons and could result in fire inside transmission line
- Can cause tremendous trickle-down damage to entire system
- Remediation process is extensive

Figure 3: Carbon Build-Up On Teflon Insulator

Minor Field Issues

- Split connectors reduce the surface area of connectivity
- Arcing will occur between connector and inner conductor
- Changes the effective spacing between inner and outer
- Impedance mismatch that will increase over time

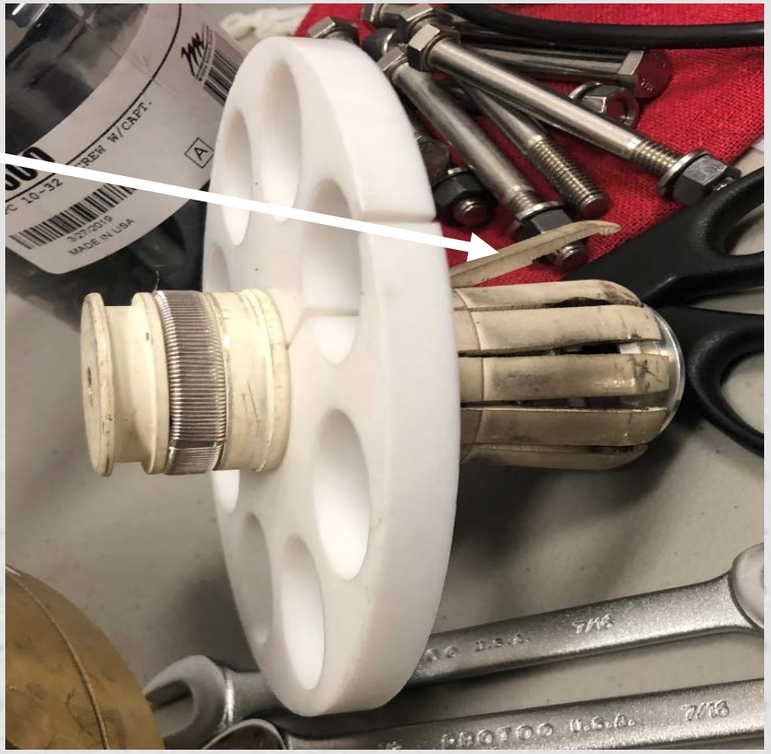
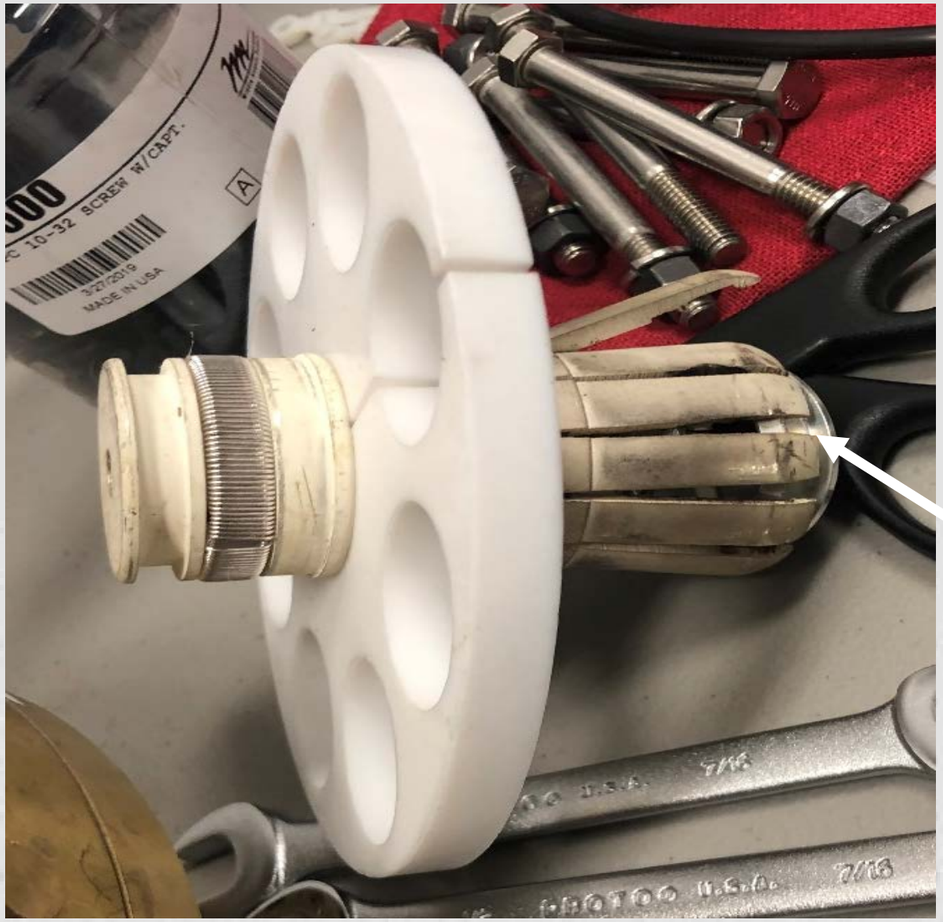
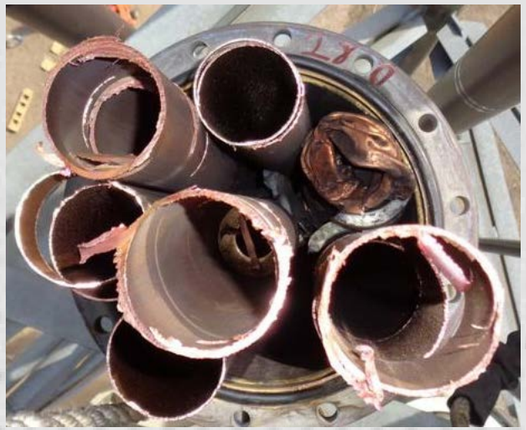


Figure 4: Split Bullet Anchor Connector

Minor Field Issues



Collateral Damage



Collateral Damage

- Transmission line bullet connector with Teflon insulator disintegrated
- No longer has a stabilizing structure to support centering the inner conductor
- Impedance fluctuation at this joint creates hot-spots

Figure 5: Melted Teflon Insulator

Collateral Damage

- Inner conductors collapsed and piled up inside vertical TL run
- Pile up caused by connector burn up at fault location
- Creates a domino effect

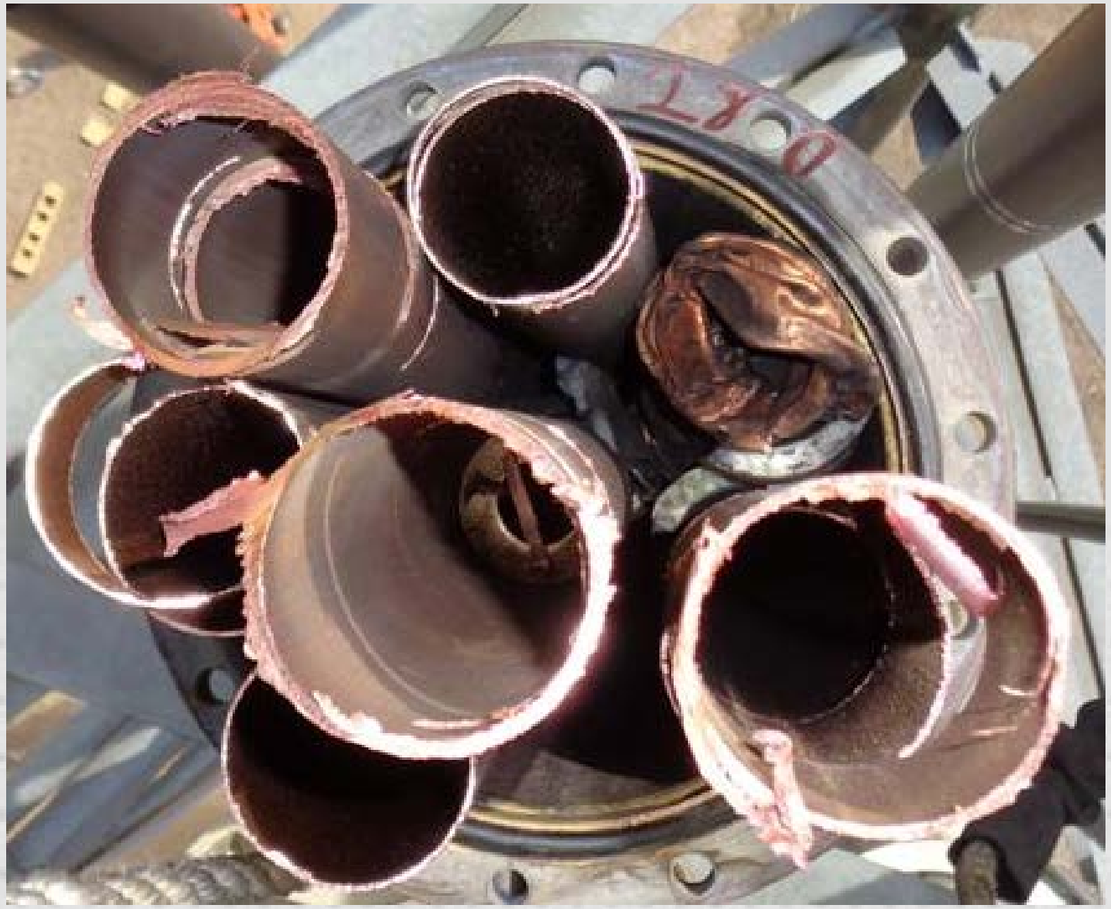


Figure 6: Collection of Inner Conductors

Collateral Damage

- Oxidization and melting Teflons result in a collection of soot down stream
- Insulators and connectors that have failed can be seen piled up

Figure 7: Collection of Melted Insulators, Inner Conductors, and Soot

Collateral Damage

- Contamination is not localized
- Creates a domino effect
- Debris will fall and continue to contaminate transmission line down hill from fault
- The process of remediation is extensive and costly

Figure 8: Debris Littered Throughout Feed System

The Goal

- Prevent Failures in the Transmission Lines
- Early Detection of Transmission Line Degradation or Frequent Arcing
- Perform Preventive Maintenance During Non-Critical Broadcast Windows to Replace Affected Components
- Minimize Downtime and Increase System Reliability
- Reduce Maintenance and Repair Costs

Current Practices

- TDR Measurements
- Forward/Reflected Power
- Arc Detectors

Current Practices

TDR Measurements

- Performed while off-air and under significantly reduced power during a system's commissioning
- This practice is used to characterize the system and to look for anomalies through broadband and narrow band sweeps
- Provides valuable information by locating faults

Current Practices

Forward/Reflected Power Measurements

- Transmitters continually monitor levels of forward and reflected power
- These measurements are used to calculate VSWR and can be displayed by a digital output on the transmitter itself
- This information can influence a system shutdown

Arc Detectors

- Identify arcing occurrences
- Ability to reduce or discontinue transmitter output power

Current Practices

Shortcomings

TDR

- Measures response of system under limited power
- Anomalies can go undetected
- Does not continue to characterize system
- Requires system shut down and field qualified engineer

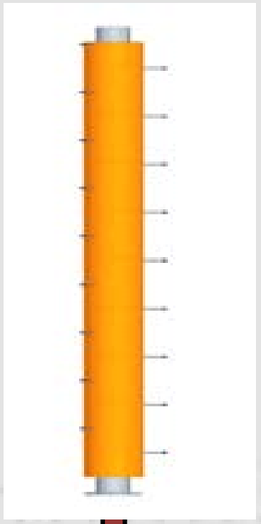
Forward/Reflected Power

- Aggregate response of entire system
- Does not localize fault
- Difficult to interpret

Arc Detectors

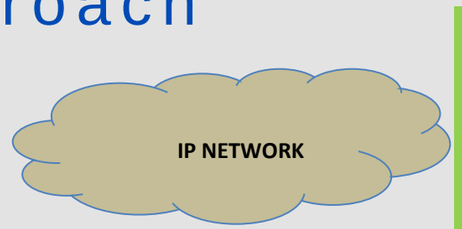
- Cannot localize arcing event

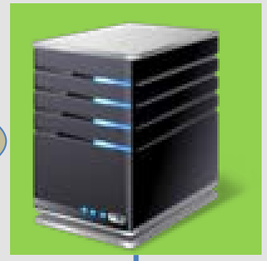
Next Generation Approach

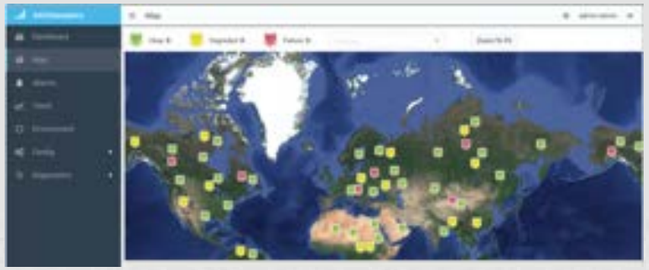


Functionality:

- Detects Discontinuities and Arcs
- Change of Quality in the Transmission Line
- Allow for Establishment of Discrete Alarms







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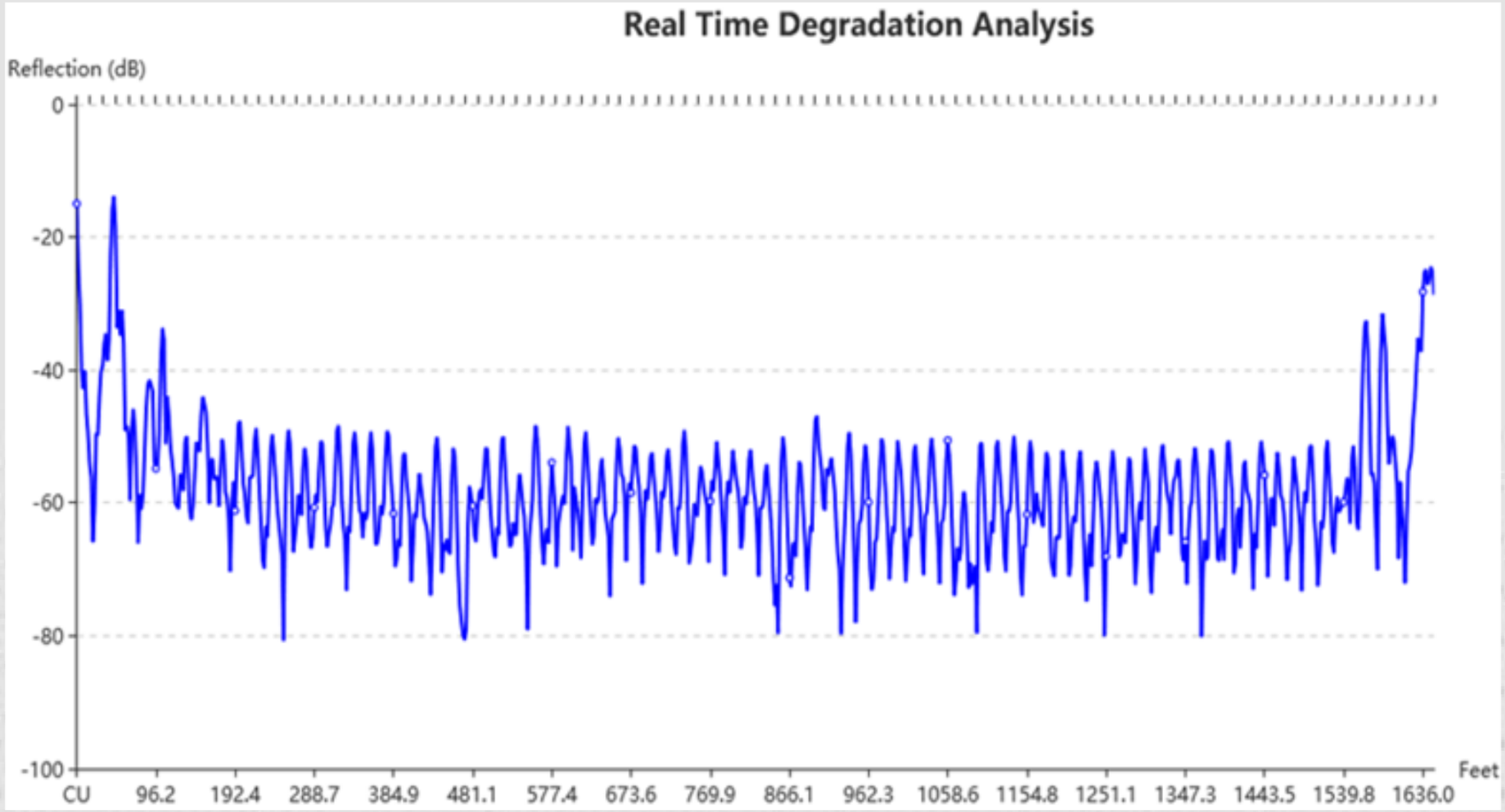
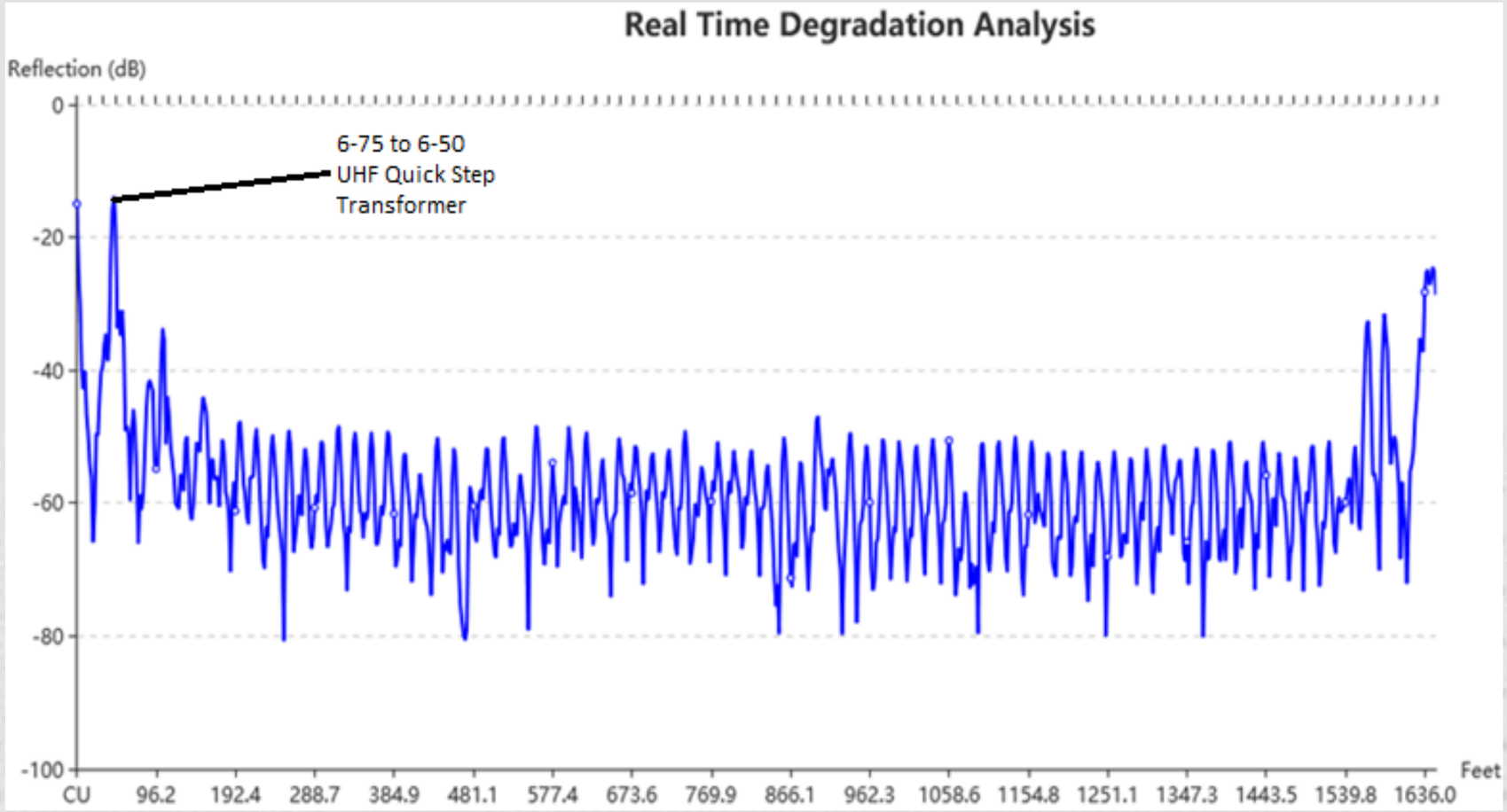
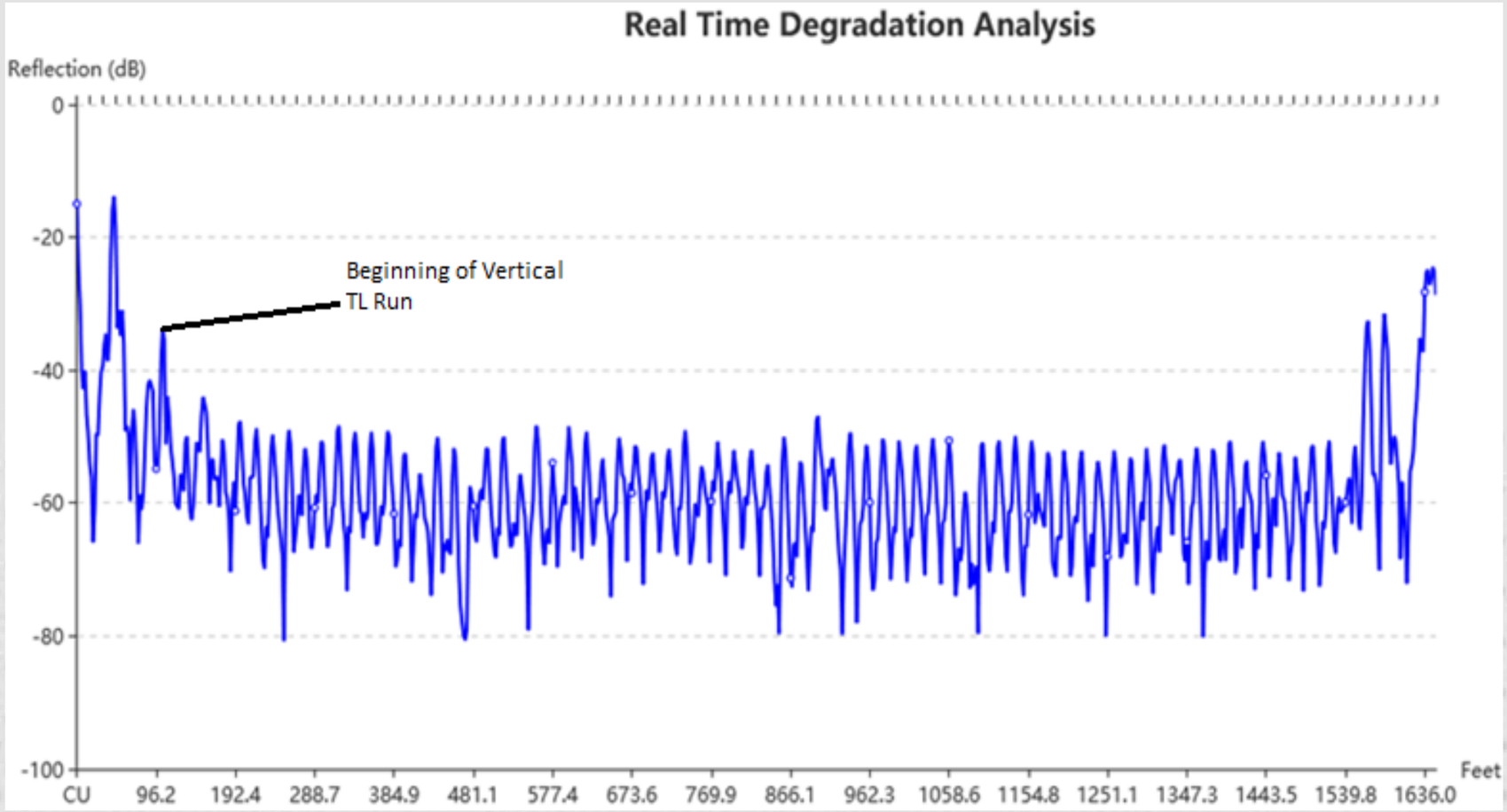
Results


Real Time Degradation Analysis
Reflection (dB)
0
-20
-40
-60
-80
-100
CU
96.2
192.4
288.7
384.9
481.1
577.4
673.6
769.9
866.1
962.3
1058.6
1154.8
1251.1
1347.3
1443.5
1539.8
1636.0
Feet

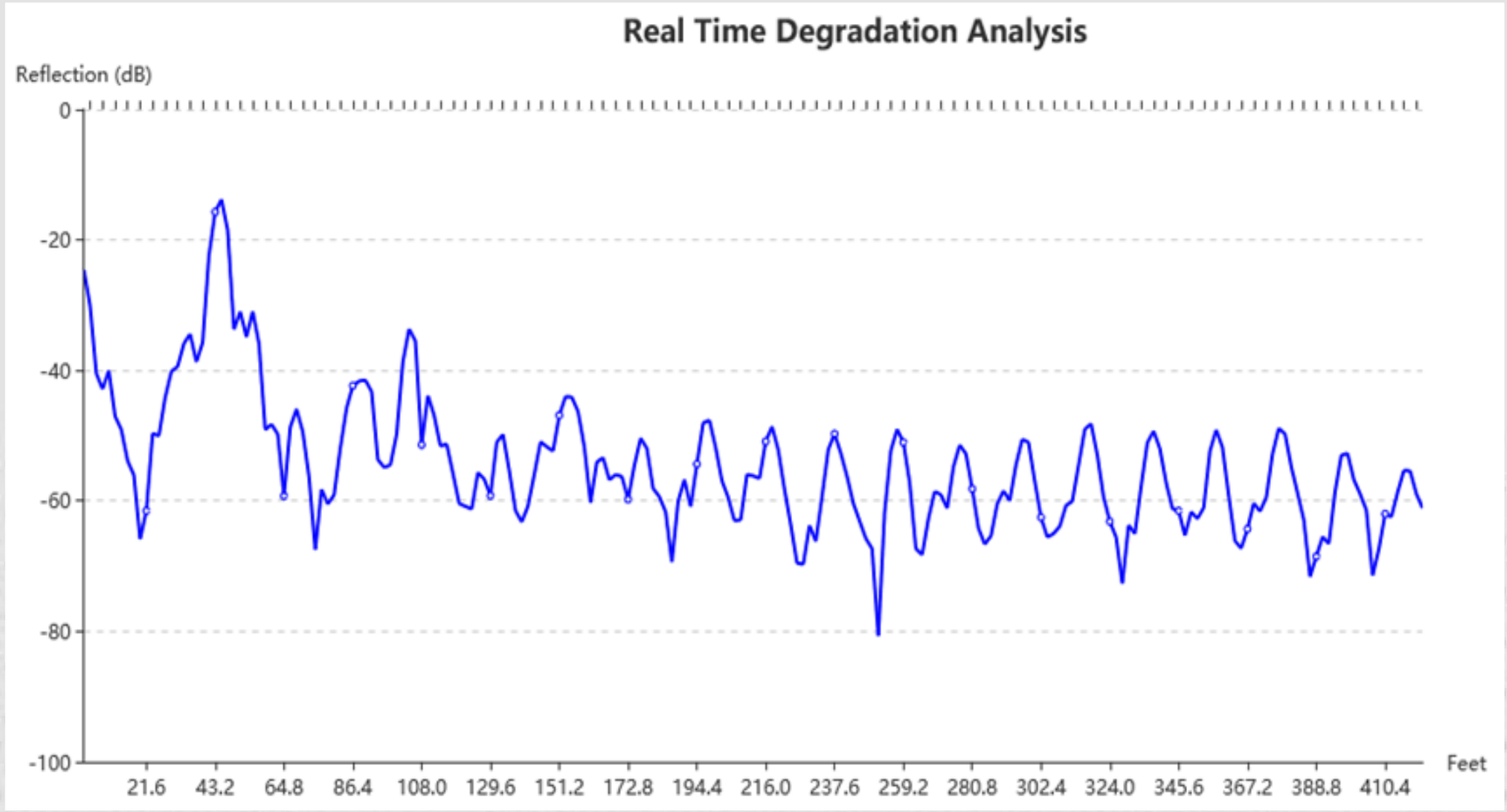
Results


Real Time Degradation Analysis
Reflection (dB)
0
-20
-40
-60
-80
-100
6-75 to 6-50
UHF Quick Step
Transformer
CU
96.2
192.4
288.7
384.9
481.1
577.4
673.6
769.9
866.1
962.3
1058.6
1154.8
1251.1
1347.3
1443.5
1539.8
1636.0
Feet

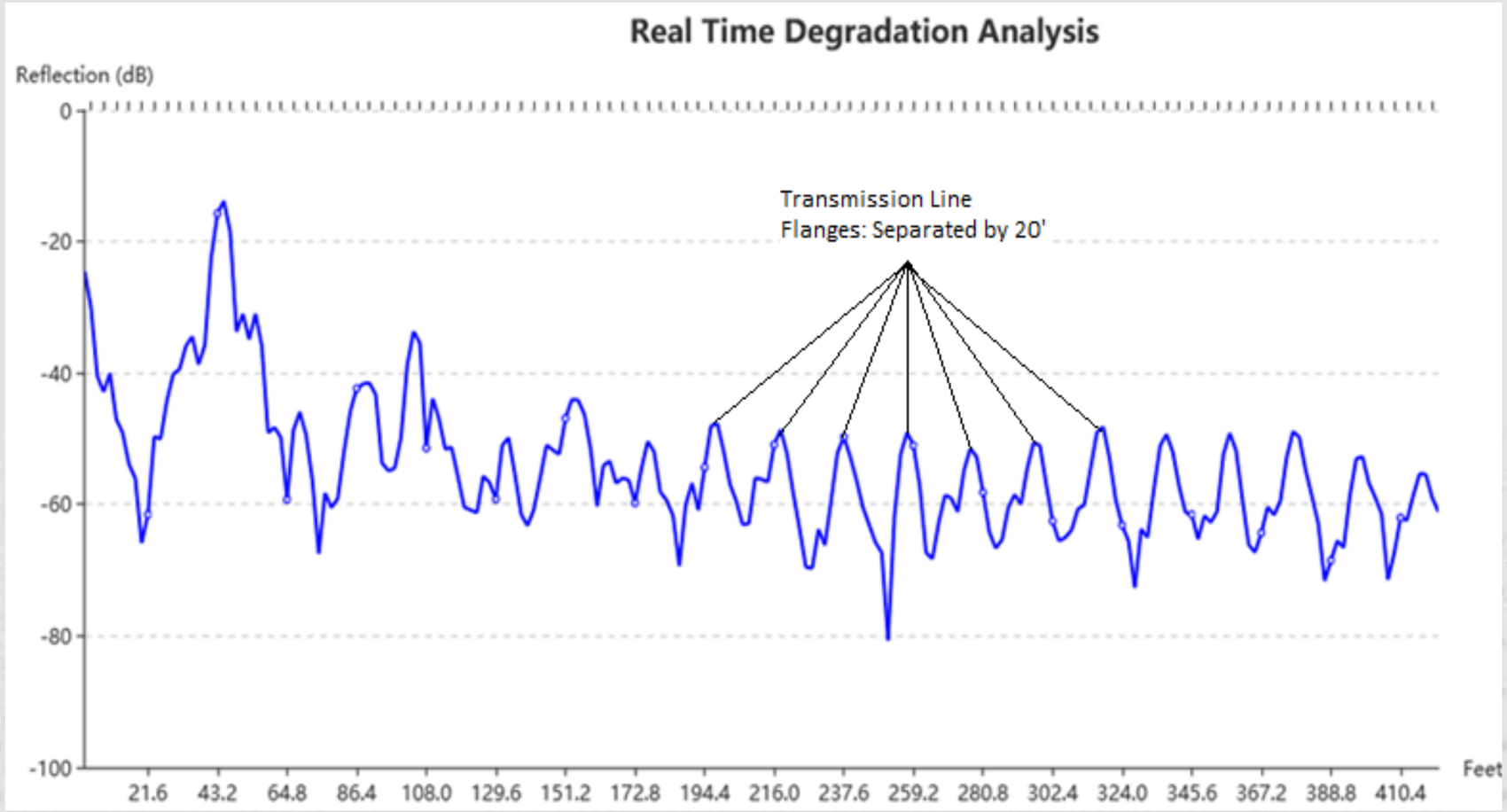
Results


Real Time Degradation Analysis
Reflection (dB)
0
-20
-40
-60
-80
-100
Beginning of Vertical
TL Run
CU
96.2
192.4
288.7
384.9
481.1
577.4
673.6
769.9
866.1
962.3
1058.6
1154.8
1251.1
1347.3
1443.5
1539.8
1636.0
Feet

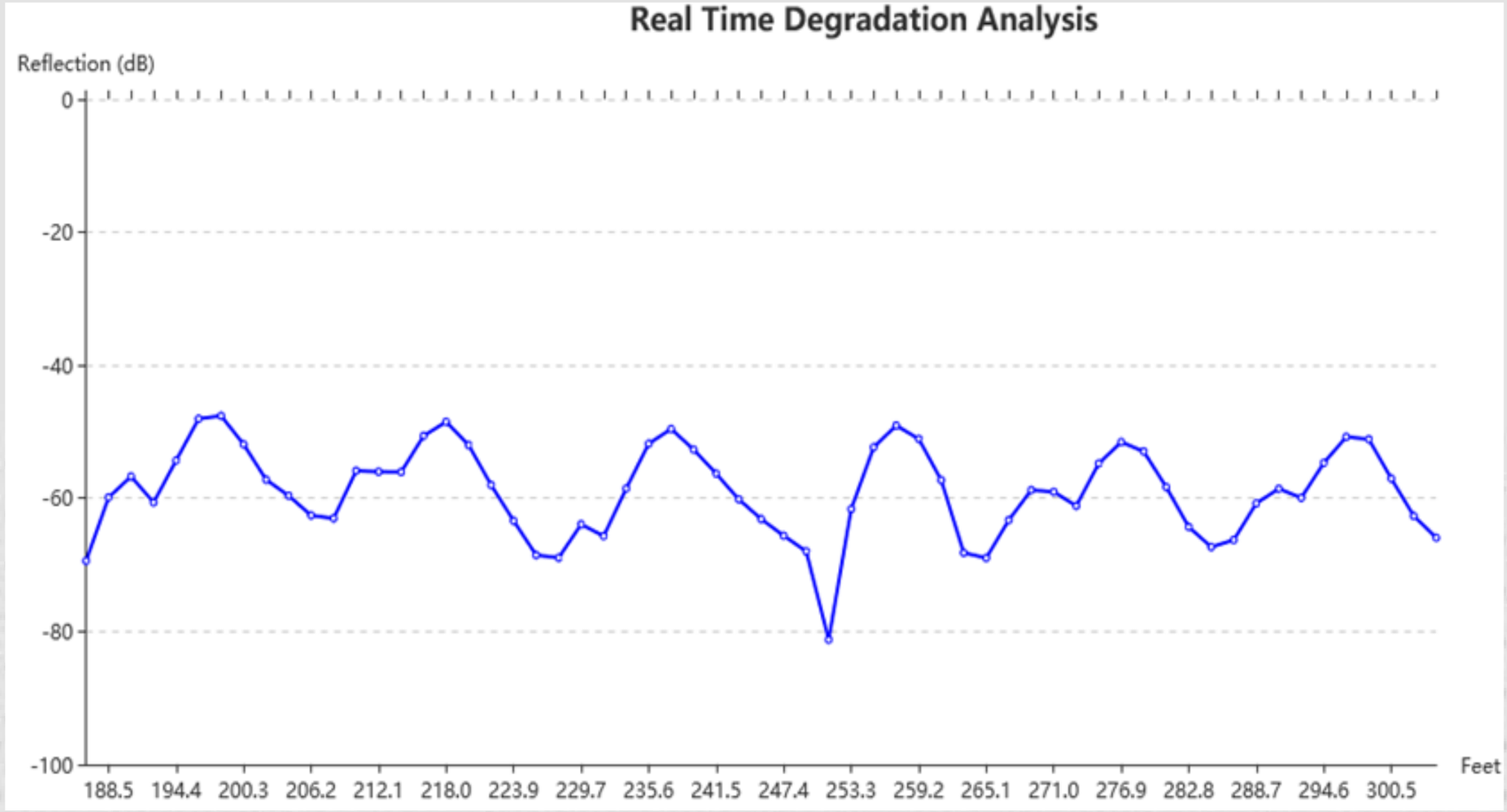
Results


Real Time Degradation Analysis
Reflection (dB)
0
-20
-40
-60
-80
-100
21.6
43.2
64.8
86.4
108.0
129.6
151.2
172.8
194.4
216.0
237.6
259.2
280.8
302.4
324.0
345.6
367.2
388.8
410.4
Feet

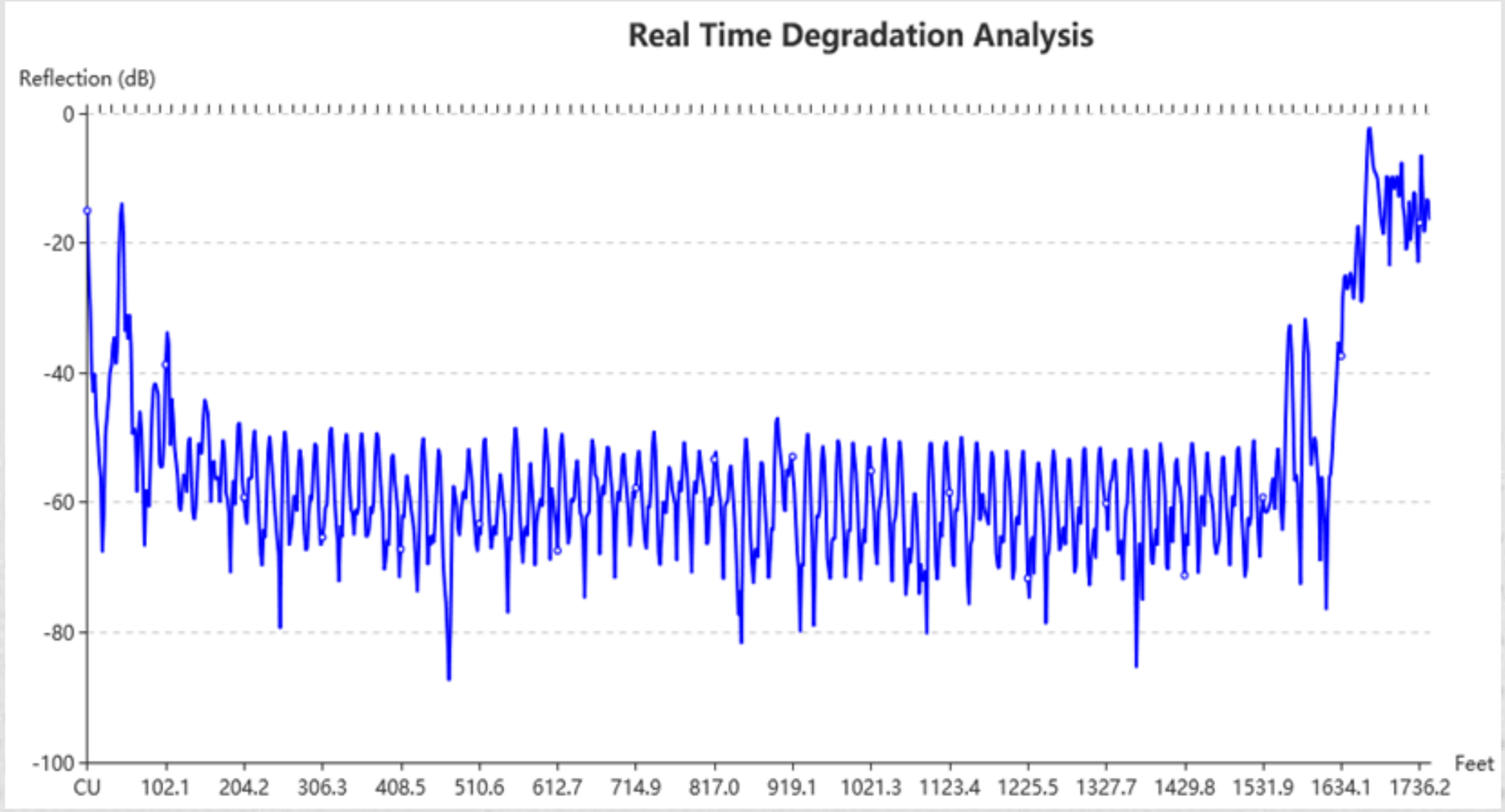
Results


Real Time Degradation Analysis
Reflection (dB)
0
-20
-40
-60
-80
-100
Transmission Line
Flanges: Separated by 20'
21.6
43.2
64.8
86.4
108.0
129.6
151.2
172.8
194.4
216.0
237.6
259.2
280.8
302.4
324.0
345.6
367.2
388.8
410.4
Feet

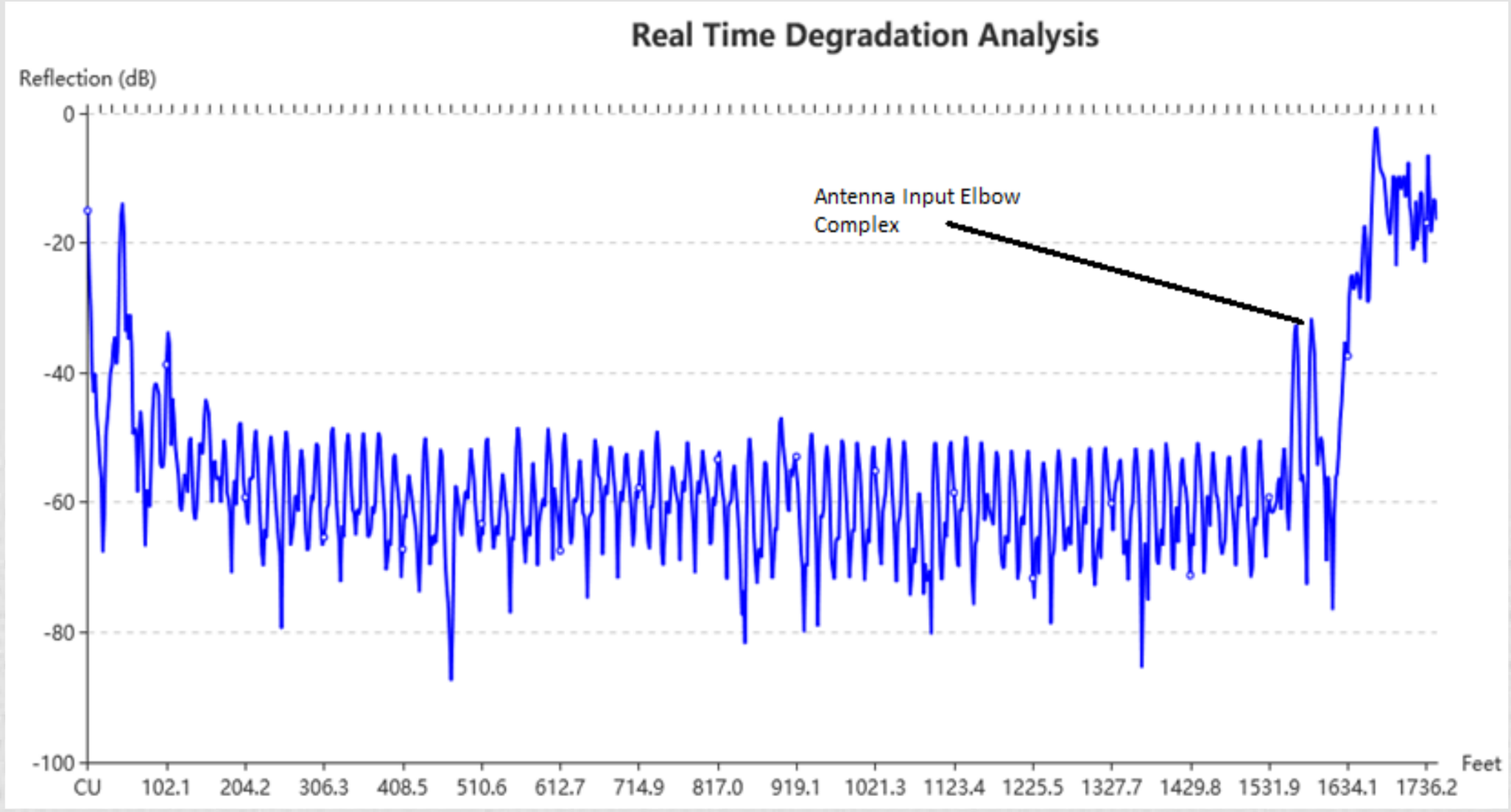
Results


Real Time Degradation Analysis
Reflection (dB)
0
-20
-40
-60
-80
-100
188.5
194.4
200.3
206.2
212.1
218.0
223.9
229.7
235.6
241.5
247.4
253.3
259.2
265.1
271.0
276.9
282.8
288.7
294.6
300.5
Feet

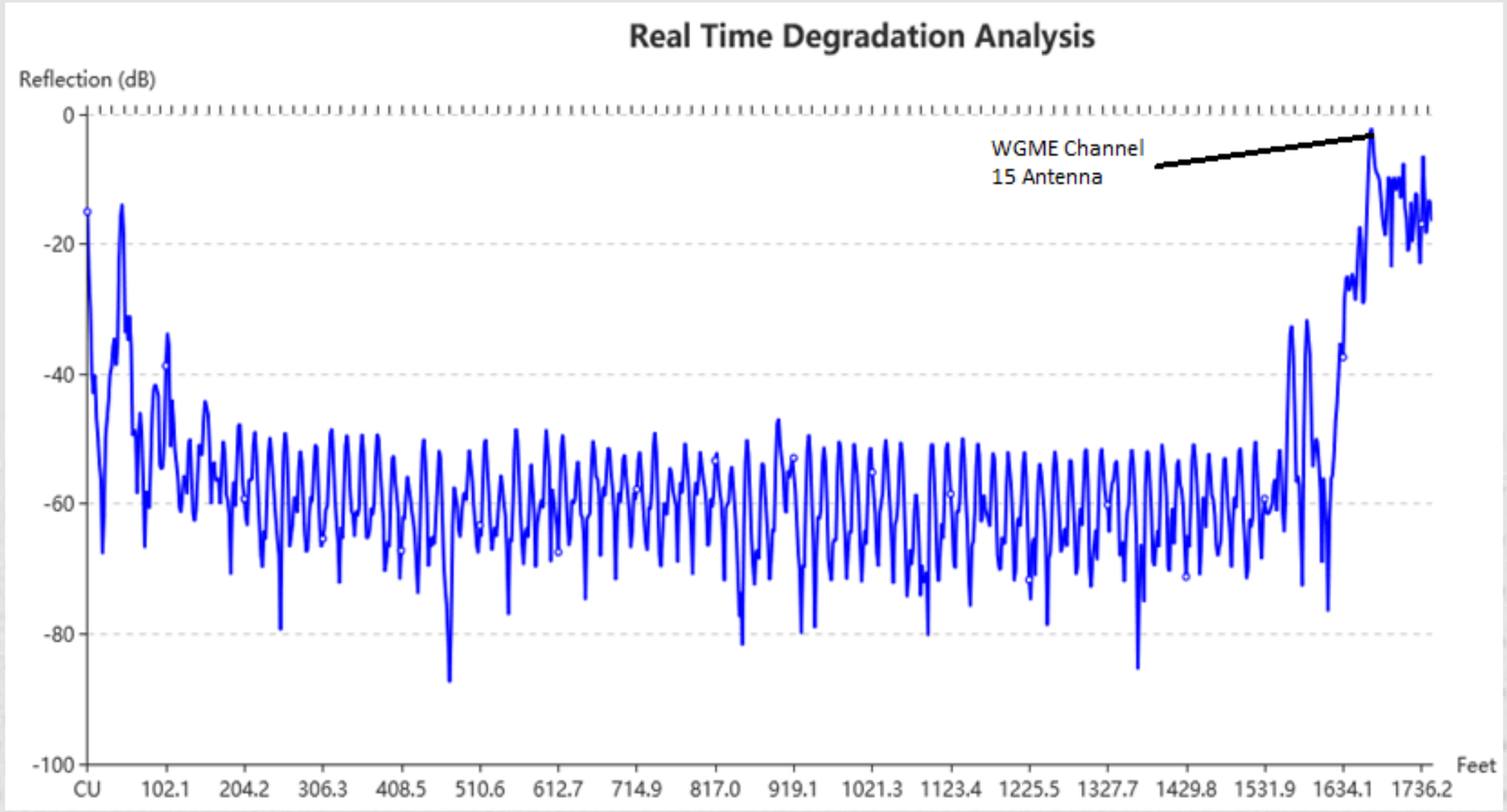
Results


Real Time Degradation Analysis
Reflection (dB)
0
-20
-40
-60
-80
-100
CU
102.1
204.2
306.3
408.5
510.6
612.7
714.9
817.0
919.1
1021.3
1123.4
1225.5
1327.7
1429.8
1531.9
1634.1
1736.2
Feet

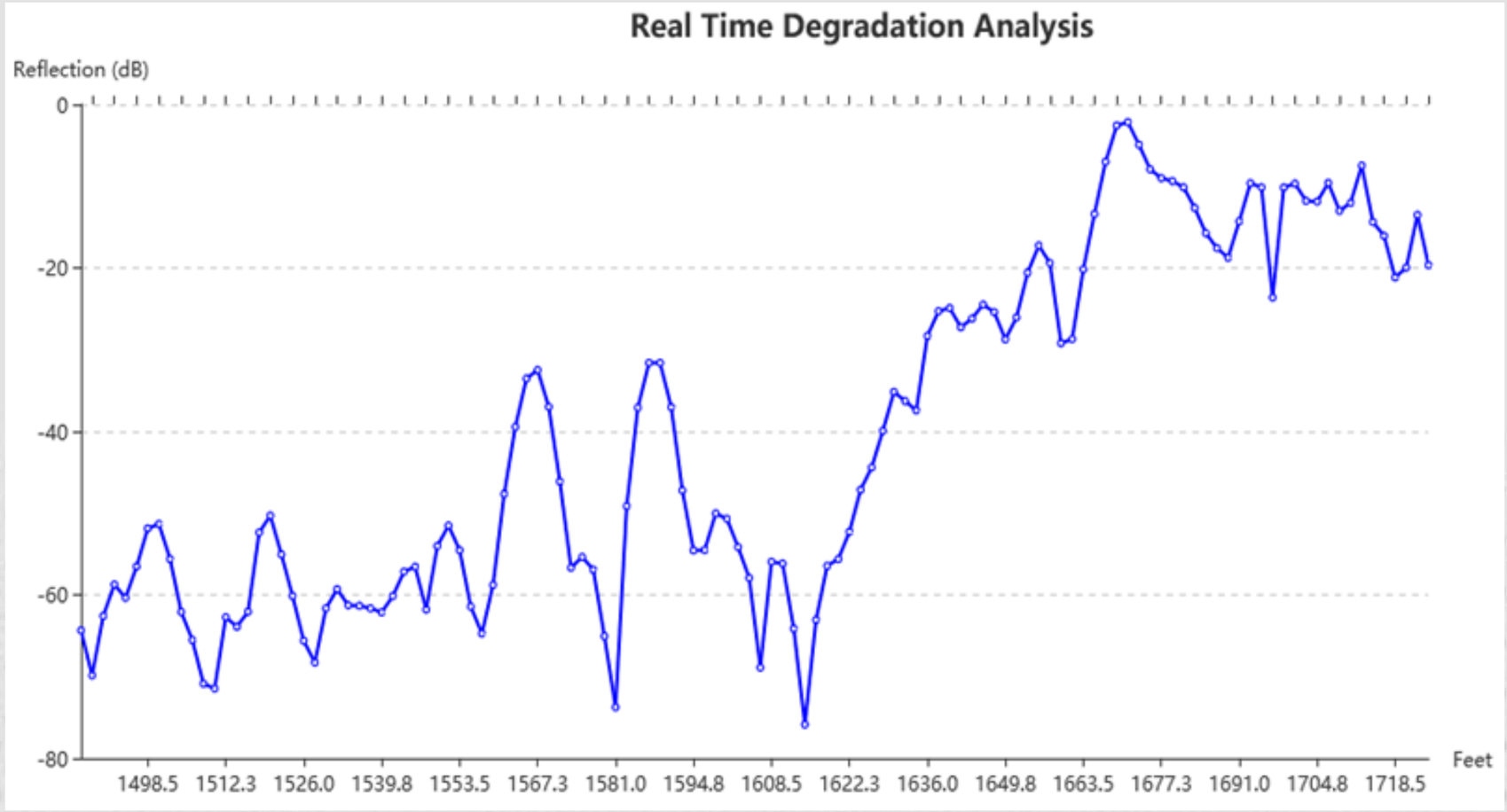
Results


Real Time Degradation Analysis
Reflection (dB)
0
-20
-40
-60
-80
-100
Antenna Input Elbow Complex
CU
102.1
204.2
306.3
408.5
510.6
612.7
714.9
817.0
919.1
1021.3
1123.4
1225.5
1327.7
1429.8
1531.9
1634.1
1736.2
Feet

Results


Real Time Degradation Analysis
Reflection (dB)
0
-20
-40
-60
-80
-100
WGME Channel
15 Antenna
CU
102.1
204.2
306.3
408.5
510.6
612.7
714.9
817.0
919.1
1021.3
1123.4
1225.5
1327.7
1429.8
1531.9
1634.1
1736.2
Feet

Results


Real Time Degradation Analysis
Reflection (dB)
0
-20
-40
-60
-80
1498.5
1512.3
1526.0
1539.8
1553.5
1567.3
1581.0
1594.8
1608.5
1622.3
1636.0
1649.8
1663.5
1677.3
1691.0
1704.8
1718.5
Feet

Conclusions

- Minor issues occur due to human error
- Collateral damage occurs when minor issues go undetected
- Current practices play an important role but are outdated
- A Real-Time Time-Domain Monitoring System has been tested and remains in the development stage to meet all broadcaster's needs

THANKS FOR YOUR TIME!

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