# THE FASTEST TOOL FOR FAULT LOCALIZATION FOR TROUBLESHOOTING THE UPSTREAM PATH

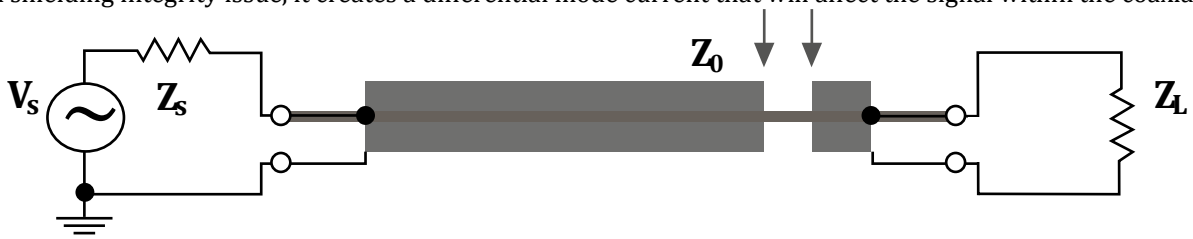
**Vastly improve technician productivity while using DOCSIS PNM Technologies and CPAT Tech Ingress Solutions.**

**GO FROM REACTIVE TO PROACTIVE**

- Increase technician productivity
- Locate faults without interrupting service
- Ongoing improvement of network performance
- Mitigate impulse noise and service calls

## BACKGROUND

Ingress, which is defined as an external signal coupled onto the outer surface of the coaxial cable shielding, generates a common mode current that is propagated along this outer cable shielding surface, and when this common mode current reaches a shielding integrity issue, it creates a differential mode current that will affect the signal within the coaxial cable.




This can dramatically reduce the reliability of upstream data connectedness in the cable network. The noise resulting from ingress, commonly known as “ingress noise”, makes up a large percentage of the total noise found in many HFC networks. In general, the upstream or return path of a HFC network is more susceptible to ingress noise than the downstream path.

The industry has made incredible progress advancing technologies to enable faster identification and resolution of potential signal transmission problems before the subscriber is impacted. Through DOCSIS 3.0 and DOCSIS 3.1 using the cable modem features FBC (Full Band Capture), pre-equalization comparisons and receiver modulation error ratios (RxMER) in the OFDM subcarriers, anomalies are found, identified and used for dispatching technicians when self-healing applications are not able to resolve the problem remotely.

These newly deployed technologies have resulted in significant improvements in customer satisfaction and workforce efficiencies. Many of the impairments can be repaired remotely without the subscriber knowing and/or disrupting service. Others can be completed with a phone call between the customer service rep and subscriber whereby instructions are provided to troubleshooting the issue at hand.

For those HFC network problems that cannot be resolved in this manner, technicians are then dispatched to the field for resolution. They are provided with all the Node Health details about the problem and given the approximate area impacted. This can be a section of trunk cable between two amplifiers, taps and node in the area. When the technician arrives he/she must physically look for the source of the problem using the information provided if the issue is still present. The process for finding errors in the field continues to improve but the “Divide-and-Conquer” method is still an important part of the procedure. No matter what you call it, the ultimate translation is trouble.

This paper compares the processes, technologies and more importantly timing of troubleshooting using the traditional "divide-and-conquer" approach, process of incorporating PNM and productivity boosting benefits of finding those same problems using the CPAT Tech Ingress Detection Solution.

## THE DIVIDE-AND-CONQUER APPROACH - TRADITIONAL

Technicians are dispatched to a troubled area equipped with an array of network information captured from the overall GIS system monitored by the National and Regional Operating Centers combined with customer service information. The return path monitoring program provides data points gathered from power supplies, nodes, and cable modems. Customer service reports, weather and traffic events are all compiled together to help optimize the truck roll. (See figure 1 below).

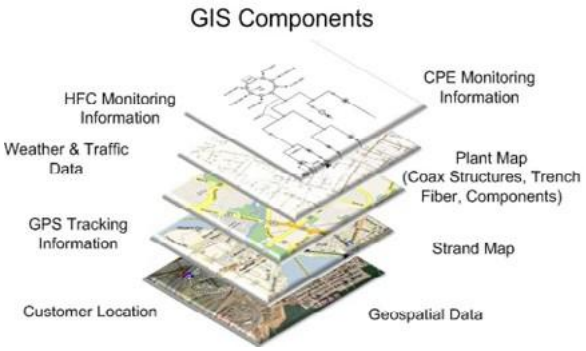



Figure 1: GIS Information

When the technician arrives at the troubled area to be repaired they begin the process of troubleshooting, typically at the last home at the end of line amplifier or node segment. Sometimes maintenance technicians are partnered with fulfillment technician at this point so that the fulfillment technician can remedy any in-home subscriber problem, whereas the maintenance technician will work on the outside plant. Starting at each tap location they begin the process of troubleshooting looking for impedance mismatches, presence of CPD, ingress, noise and other shielding integrity issues. As they complete testing at each tap and drop, they move up the feeder cable to the next tap and continue to the amplifiers, and onward to the node.

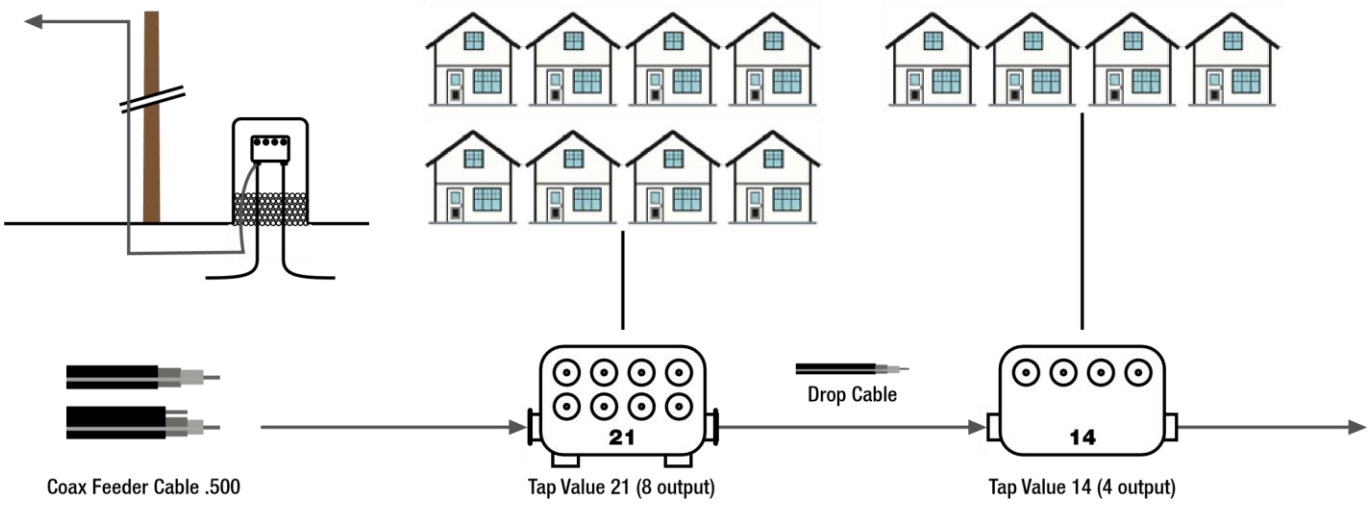



Figure 2: Tap to Home Network

If they discover that the problem is originating from inside the home, the fulfillment technician will try to gain access to the subscriber while on site to look for problems within the premise. If they cannot gain access, then customer service is alerted to schedule a time with the subscriber at a later time.

If the problem is found to be upstream from the tap network, then the maintenance technicians continue the process of elimination as they work up the feeder to the amplifiers and nodes. As they eliminate each segment or component of the network they continue upstream until they find and are able to repair. (See components in Figure 3: Node to Tap Network).

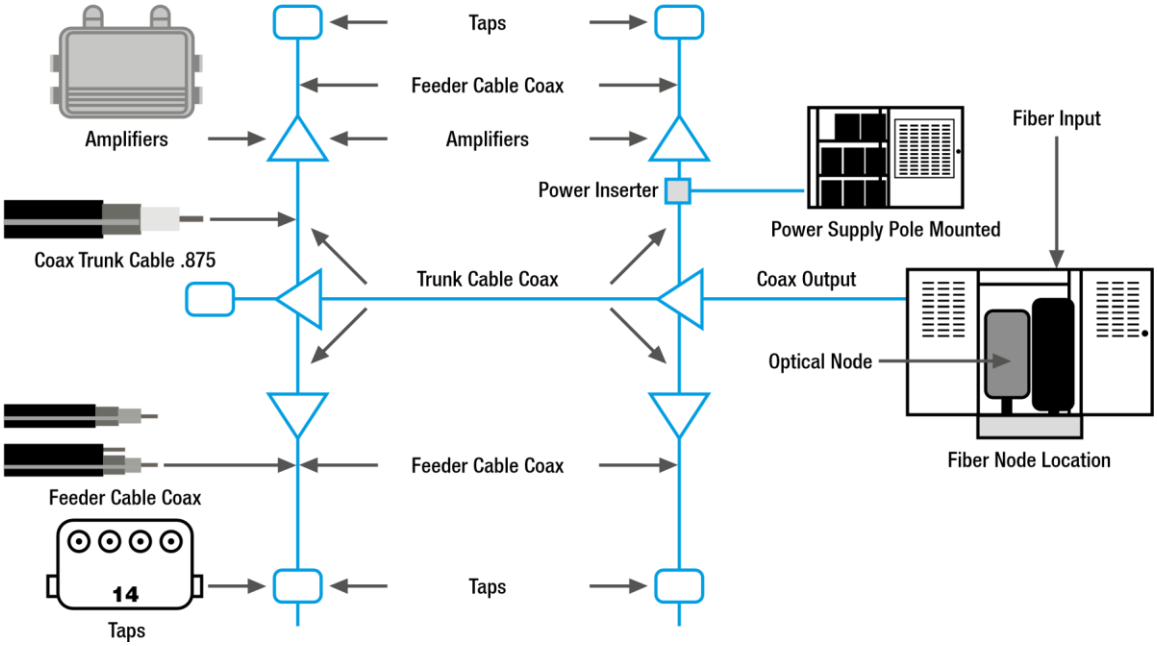



Figure 3: Node to Tap Network

The technicians connect their respective tools to the network at the tap, amplifier or node locations to check all the levels and run their tests. (See Figure 4: Typical Tools Carried by Technicians).

## Signal Level Field Meter

The field meter is used to provide the technician with readings at each location of MER, SNR, noise, ingress, tilt, and provides a snapshot of the condition of the downstream and upstream data at each test point. It also tells the technician when the condition has been cleared.

## Egress, leakage detectors

Leakage is a two-way phenomenon; when signals can get out, over-the-air signals can also get in. Signal leakage events are captured continuously through continuous patrolling and ride-outs of maintenance technicians and other assigned vehicles. The egress detector is used to locate points of leakage such as damaged cable and loose connectors. Often once the source of the leak is found and repaired the network issues are resolved. However, resolving leakage doesn't always fix ingress. There is no correlation between the two, often close to 47% of the time ingress occurs where there is no egress.

### CPD

Searching for Common Path Distortion is useful in tracking down anomalies as CPD can occur when there is no external or visible damage to the cable or connectors. The distortion can be contained completely within the cable. Also, the network strand maps must be kept up to date or the data provided won't be accurate.

### TDR

Using a Time Domain Reflectometer (TDR) requires that the service be disconnected. The TDR pings the cable looking for reflection from an impedance mismatch and is able to calculate the distance to the source of the problem from the test point. Some of the other tools incorporate a TDR option thus eliminating this as a separate tool.

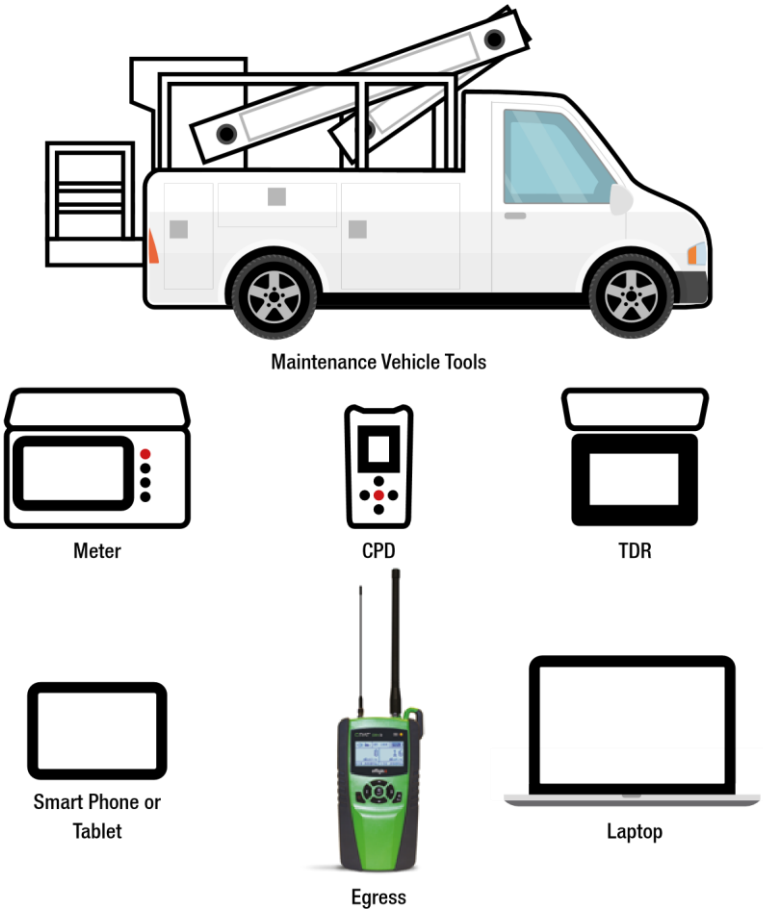



Figure 4: Typical Tools Carried by Maintenance Technician

## THE DIVIDE-AND-CONQUER APPROACH – AND PNM TECHNOLOGIES

DOCSIS 3.0 and DOCSIS 3.1 technologies capture valuable transmission data that can narrow down the fault location to a trunk line between amplifiers, or feeders connecting a section of homes. This eliminates testing of all amplifier or node legs and narrows it down to one area. The technician can then use the divide-and-conquer approach starting in that narrowed down area. This in principle should reduce the troubleshooting time significantly, perhaps never extending beyond hours into days or weeks.

## CHALLENGES

- Lots of deployment and training required to optimize the benefits of these technologies.
- Older DOCSIS CPEs location data is often inaccurate and unreliable.
- Disconnected subscriber locations often remain connected to the network. No cable modem = zero visibility from PNM perspective.

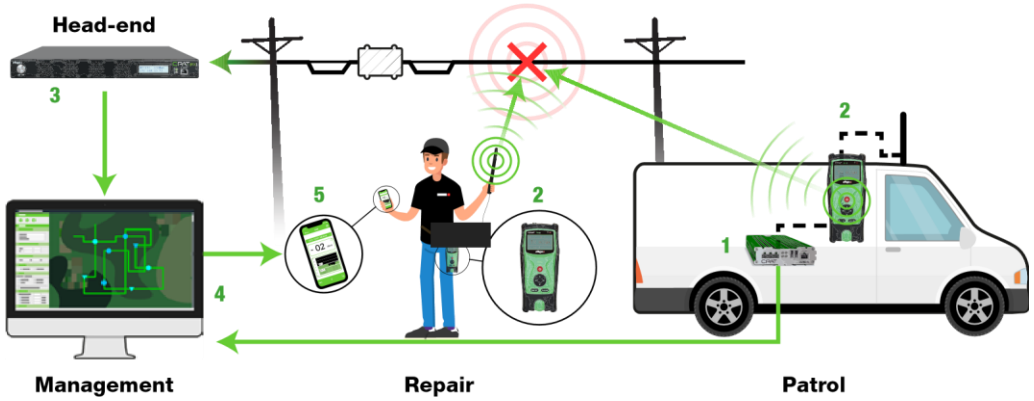
## THE CPAT Tech INGRESS LOCATOR APPROACH

The CPAT Tech Ingress System is the fastest tool available on the market for locating upstream ingress noise and partial CPD issues. The Ingress events are located within minutes as opposed to hours or days as with the traditional divide-and-conquer approach. Ingress is commonly intermittent and thus difficult to locate when taking readings with a meter. The CPAT Tech (ITX2) generates a continuous ingress test signal and detects faults in real time. The technician can locate the ingress source immediately.

During patrol-mode ingress points are detected and plotted on a map providing location, level data, and timestamped of the ingress touchpoint. The location data provides an approximate physical address of the point of ingress directing the technician to the issue without having to do any troubleshooting. The technician then removes the ingress transmitter (ITX2) from the vehicle and does a walk-out to the point of ingress directed by the audible tone pinging from the mobile app. (See Figure 5: CPAT Tech Ingress Detection Solution).

Since the ingress test signal is generated in the coaxial network it will detect ingress noise in portions of the network where exsubscribers are connected. These scenarios occur approximately 1/3rd of the time. Operators leave drops connected so that subscribers can do self-installs.

Using the CPAT Tech Ingress toolkit there is no need for disconnecting the service in order to find the points of ingress. All the data is collected and plotted on the map enabling the technicians to organize their maintenance efforts more efficiently.




**1-2** The ITX2 transmits during drive-out while the ARD4 records the ingress level, location and time. Data is correlated to CPAT Web when a Wi-Fi or cellular connection is made.

**3** The IRX1 in the head-end captures the signal generated by the ITX2 that enters the return path.

**4** The IRX1 processes data and uploads to CPAT Web, creating ingress data events on the geo-referenced map.

**5** CPAT Web transmits back to the mobile app device for the technician to walk (2) to find the ingress point.

Figure 5: CPATFLEX Ingress Detection Solution

CPAT Technologies inc. gathered data in 2019 (Jan-Dec) from customers using both our Leakage and Ingress detection solutions. The data metrics revealed that ingress occurs about 47% of the time with no egress present and vice-versa, egress occurs the same proportion with no ingress present. (See Figure 6: Ingress vs Egress Occurrences). The ingress solution combined with the egress solution provides the most amount of information for finding problems without interrupting service.

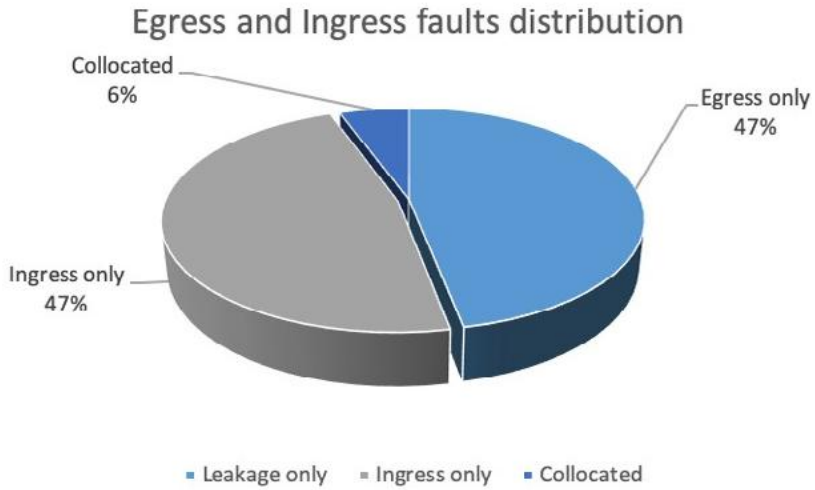



Figure 6: Ingress vs Egress Occurrences

## PRODUCTIVITY COMPARISONS

- The time to physically locate problems in the field using the traditional divide-and-conquer approach can range from hours to days to weeks depending on the situation. If the entire node area needs to be searched this could take weeks to find. All of this time searching for the problem takes away from the time required to repair the problem and other problems needing attention. Productivity inefficiencies.

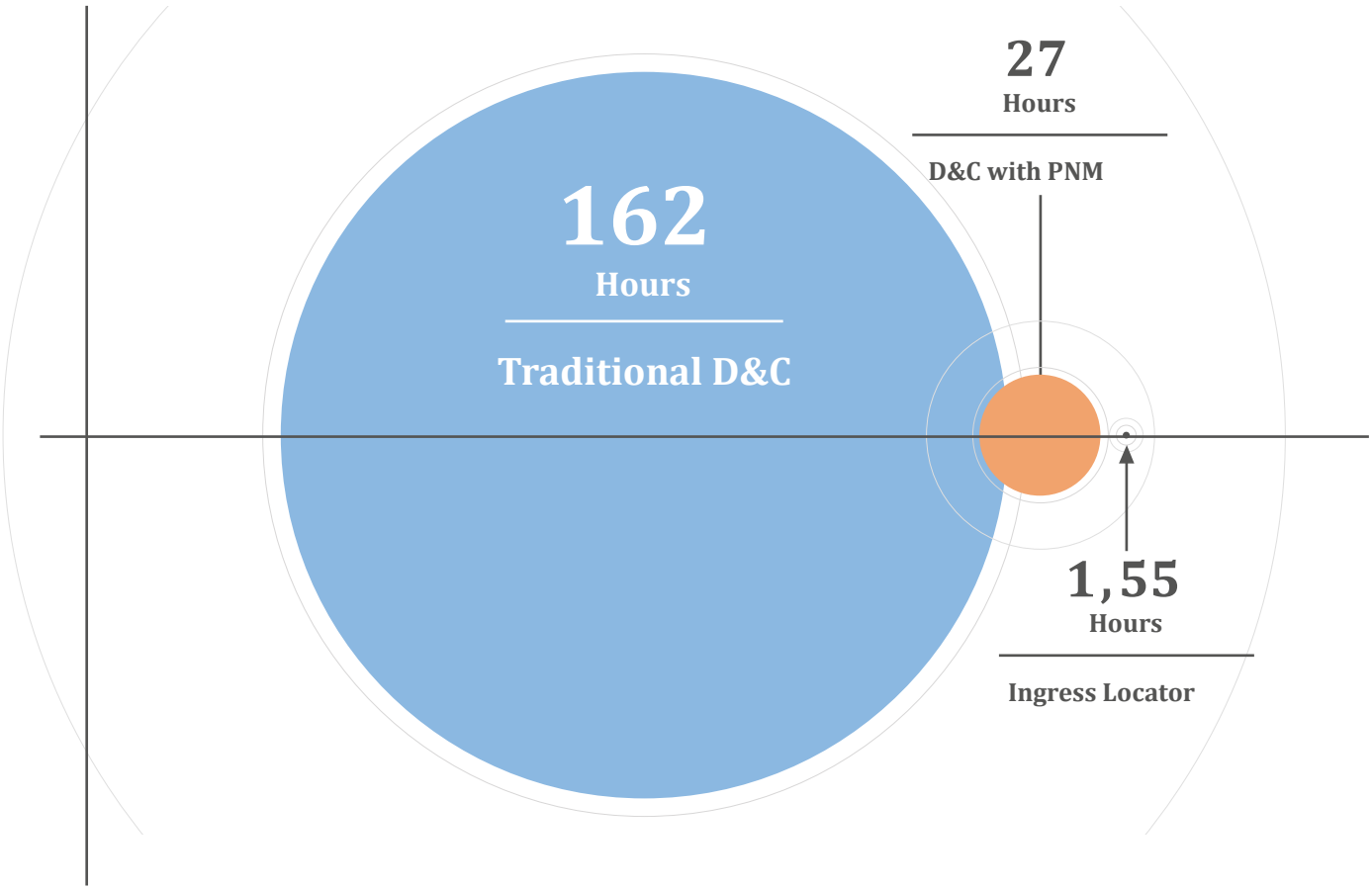
- Information collected using PNM technologies vastly reduces the search area for the technician. This decrease the time to find the problem using the divide-and-conquer because the problem has already been isolated to a select area of the node. The data from PNM produced by cable modems upstream enables areas to be eliminated in a service area. In theory this should reduce the search time to hours and in some cases days to find. Again, slight productivity inefficiencies.

- Using the CPAT Tech Ingress Locator tool the problems are located in minutes not hours or days. The technicians are able to locate the point of ingress immediately and can then spend more time repairing and being proactive while moving on to other troubled areas.

- The comparison below, 10 trouble tickets were hypothesized to illustrate the time differences in minutes using the three approaches. The traditional divide and conquer approach searching a large node or amplifier area took at total of 9720 minutes for the 10 tickets. That's 20 ½ days of searching. Using PNM that total dropped to 3.37 days of searching. Keep in mind the PNM data doesn't report on inactive subscriber connections so this time can expand and contract considerably if the sources of noise and ingress are originating from those connections.

- The ingress locator tool found all 10 errors in a total of 93 minutes or 1.55 hours. Clearly saving hours of search time. Tech productivity sky rockets when using the Ingress toolkit.

Total Comparison Time Over 10 Work Orders (Time in Hours)




## KEY BENEFITS OF DEPLOYING INGRESS DETECTION SOLUTION

- No disconnecting sections of the HFC plant.
- Increased technician productivity. Technicians find the point of ingress in minutes instead of days or weeks.
- Approximately 1/3 of return path ingress and noise originates from former subscriber connections. The ingress tool will find these problems, PNM will not.
- Always transmitting it's not intermittent like Ingress.
- https://www.cpat.tech/en/solutions/ingress-detection-solution/