

Passive Intermod Interference is real; it will grow to cause more problems as 5G and more spectrum are deployed, and the costs are substantial

This paper will summarize a DETECT-RESTORE-SOLVE (DRS) Best Practices approach to the mitigation of Passive Intermod interference (PIM) in a wireless network as it occurs. When PIM occurs, it costs the Mobile Network Operator real expense dollars to identify and resolve it, it reduces valuable cell site coverage and capacity, and it degrades the subscriber experience while it is present.

This paper is not focused on the definition of PIM, the fundamentals of PIM or its causes, we leave that to numerous other published materials.

PIM Costs Real Dollars

The presence of PIM reduces the amount of traffic carried and therefore the amount of revenue generated by a cell site. This reduction in revenue is a real cost of PIM to the Mobile Network Operator. A second real cost is the expense to find and resolve it. Let's look at the cost of lost capacity. To demonstrate this, we will use an example with simple numbers. The assumed numbers in bold type can be replaced with numbers specific to the network being analyzed to show the costs for that network. In any case, the principle is the same, there is a real cost incurred when PIM appears and while it persists.

EXAMPLE:

- A GB (gigabyte) of data from a typical cell site delivers **\$1** of revenue to an MNO
- A typical cell site carries **1,000** gigabytes of traffic a day
- *By calculation, the value of carrying a GB of data equals \$1,000 of revenue a day*

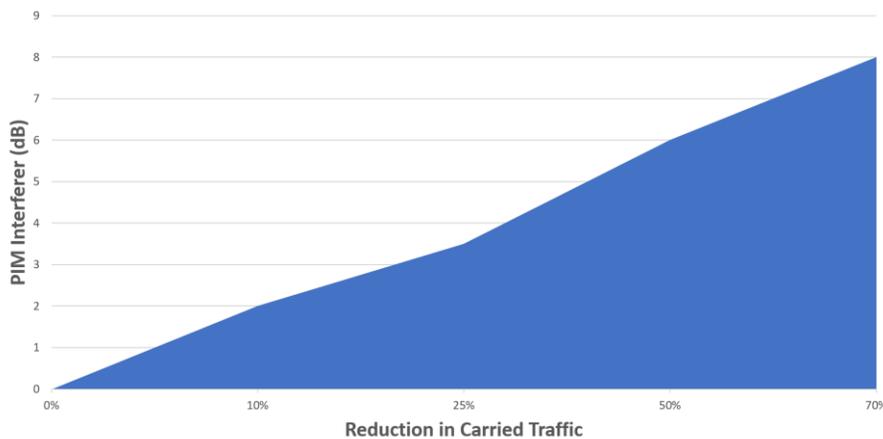
Gained from hundreds of field analyses and first-hand customer engagements, ISCO knows as little as 6dB of PIM on an uplink channel can reduce traffic carried by 50%. Using the assumptions outlined above, the cost can be easily calculated:

- A 6dB PIM interferer reduces traffic carried by **50%**
- *Therefore, a 6dB PIM interferer can cost an MNO \$500 a day, \$3,500 a week or \$182,500 a year from a single site*

When PIM occurs it usually affects more than one site, multiplying the real cost incurred by the MNO. Further multiply by the number of days the PIM persists and you can see the annual cost

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of PIM on a wireless network is real, adds up fast and could be significant. Regardless of the exact costs specific to each MNO, leaving PIM to degrade the network for any period of time is costing MNOs real cash, compromising the integrity of their network and negatively impacting the subscriber’s overall experience through reduced accessibility and throughput -- and increasing customer churn. Plus, it interferes with the speed and connectivity benefits promised from 5G.



The impact on KPIs as PIM increases

The example used is for illustrative purposes. The exact costs and carried traffic are specific to each MNO and each site. A similar revenue-based calculation can also be created using exact numbers for a specific MNO. In all cases the principle remains the same – PIM is a real cost to an MNO.

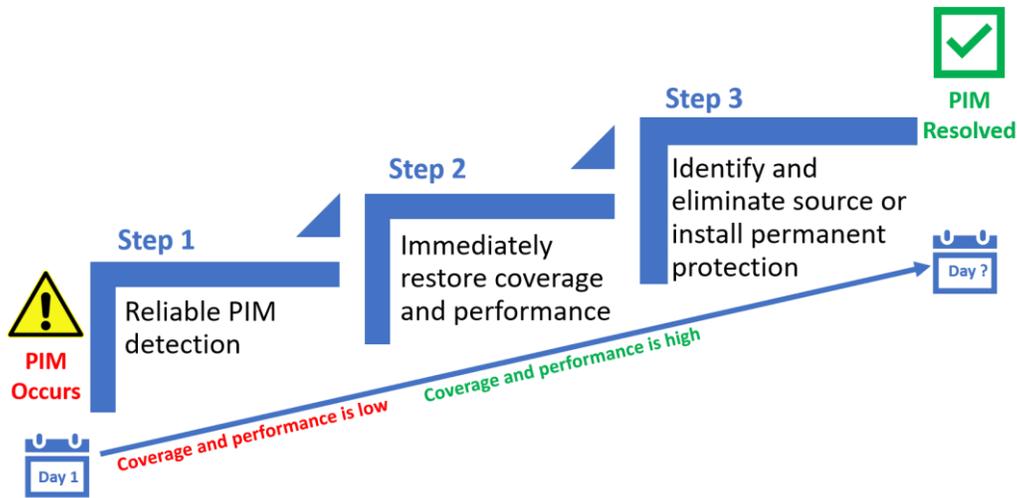
In this paper we will introduce the DETECT-RESTORE-SOLVE (DRS) Best Practices methodology. DRS is a process of Detecting PIM impairments in spectrum, immediately Restoring coverage, performance and subscriber experience, then efficiently hunting down the PIM source and eliminating PIM to Solve the situation.

Passive Intermod interference is a reality and will impact 5G as much as 4G LTE. Due to more spectrum being used, mid-band 5G with wider carriers and the growing number of cell sites, the occurrence of PIM will continue to increase. The objective of DETECT-RESTORE-SOLVE is to eliminate PIM and its degrading effects as quickly as possible to reduce the costs and minimize the impact on subscribers.

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DETECT-RESTORE-SOLVE Process (DRS)

DRS is a Best Practices methodology to detect the presence of PIM efficiently and reliably and immediately restore the integrity and performance of the network.



The DETECT-RESTORE-SOLVE Process

Step 1 - Reliably DETECT PIM

The first step of the process is to reliably detect PIM on a timely, real-time basis when it starts occurring and impacting the network. Up to now, many MNOs only realize PIM is occurring after it is already impacting performance and subscriber experience, by reviewing KPI reports. While this is a proven methodology, it is prone to delay, letting the PIM degrade the network and impact subscriber experience for weeks or possibly months before any action is initiated. In addition, this approach requires a highly skilled expert technician or optimization engineer to accurately diagnose the situation.

Diagnosing the situation is the essential first step. Many types of interference exist in 5G as well as 4G networks with harmful impacts. For example, PIM, wideband, cell-edge co-channel pollution, narrowband and adjacent channel leakage can all exhibit similar symptoms, but each requires completely different steps to resolve and eliminate. Using KPIs can be time consuming to analyze and can sometimes be misleading especially when only viewing RSSI and SINR. While both RSSI and SINR may be degraded their condition only reveals a limited amount about the actual spectral condition that needs to be resolved.

Today there are home grown and off-the-shelf software tools that are being used to help detect and alert network operators to the presence of PIM and many other types of interference.

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These tools can help more quickly identify possible issues and prioritize the multiple spectral challenges when they occur simultaneously. Additionally, by applying guidelines already established by the mobile network operator during network optimization, the software tools can calculate the degradation to the network, further helping network technicians to prioritize their efforts.

Step 2 - Immediately RESTORE

Once PIM has been identified and confirmed in the network, its impact is now real -- the cost of missed traffic is incurred, subscriber experience is degraded, capacity and coverage are lost; the cost starts piling up. Step 2 of the DETECT-RESTORE-SOLVE approach uses ISCO's ProteusCPRI Portable to restore network performance and coverage so impact to subscribers and cost are minimized, see Figure 1.

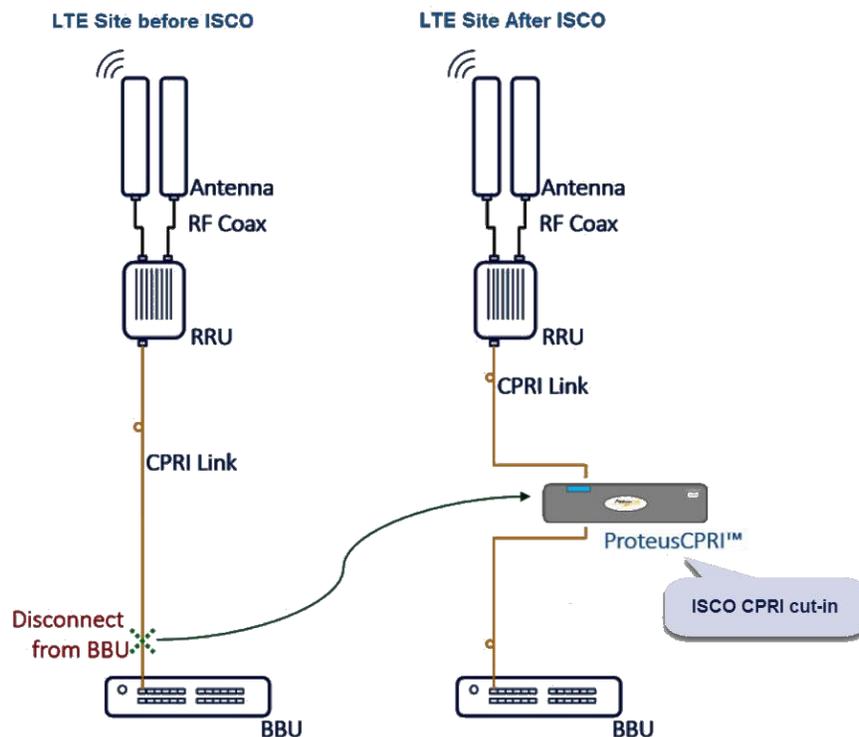


Figure 1. Inserting the ISCO ProteusCPRI conditioning server in line to immediately begin cancelling PIM to restore coverage, capacity, and subscriber experience.

With the ISCO ProteusCPRI conditioning server installed, the network technician can focus their attention on the activities to hunt down and permanently eliminate the source of PIM without worrying about network performance and subscriber experience. The technician will have information about the PIM level and spectral conditions that will contribute to the PIM hunting and resolution activities that will Solve the problem. Figure 2 shows the information about PIM

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available remotely to a technician to assist with quantifying the amount of PIM and confirming when the PIM problem is Solved.

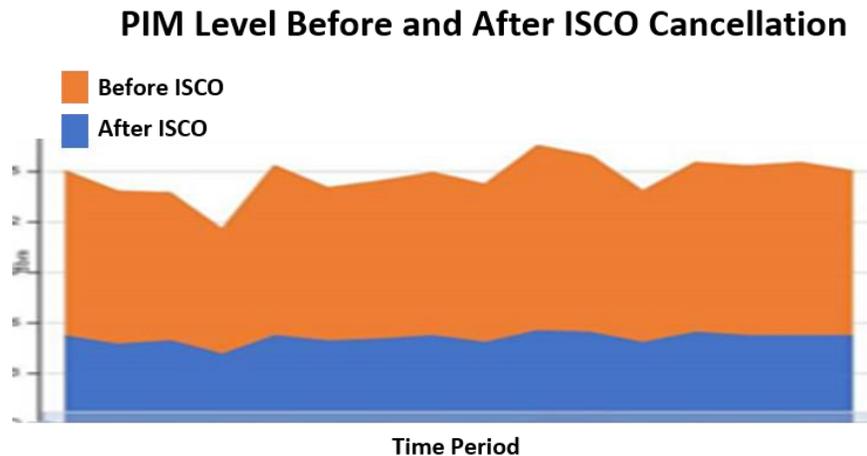


Figure 2. Monitor-Canceller view from ProteusCPRI shows the amount of real PIM before and after ISCO's PIM cancellation is applied

The graph shown in Figure 2 shows the level of PIM detected by the ProteusCPRI server, confirming the presence of PIM. This is helpful since it is critical to know the type of interference to be hunted and eliminated. For hunting non-PIM sources of interference, PCTEL's SeeWave® interference locating system is an efficient handheld solution. Also shown in Figure 2 is the level of PIM after ISCO's PIM cancellation software has been applied to the signal. Information from the ProteusCPRI server helps determine the severity of the impact, assess the performance that can be recovered, prioritize remediation activities, and ultimately confirm the PIM issue has been resolved.

Step 3 - SOLVE

With the network restored, along with information from PIM and interference detection software tools, the technician can focus their full attention on hunting and resolving the issue at the source to eliminate the problem permanently, if possible. This step involves using the test equipment to find the actual source, then taking actions to eliminate the PIM, then using the test equipment along with ProteusCPRI to verify it has been permanently eliminated or reduced to an acceptable level.

On a targeted basis armed with information from the detection software tools, the technician locates the PIM using the PIM test equipment. Once a PIM source is located, the technician will then execute a process of trying different remediation techniques followed by retesting until the PIM is eliminated or significantly reduced. The actual remediation techniques are many and

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beyond the scope of this paper. PIM remediation techniques and processes are readily available from published sources.

After the source has been identified, if PIM can be eliminated or reduced to acceptable levels, the ProteusCPRI Portable conditioning server can be removed. Prior to removal, the technician can again review the PIM monitor-canceller view from the ProteusCPRI to assess the extent to which the PIM has been mitigated. Once the server is de-installed, the technician can move to the next PIM incident and initiate a new DETECT-RESTORE-SOLVE cycle.

In some cases, PIM cannot be resolved at the source due to environmental constraints, regulatory issues or when lengthy negotiations are required to eliminate the source. In these situations, the ProteusCPRI can then be permanently installed to ensure PIM is eliminated and the network continues to perform as desired. When permanently installed, the ProteusCPRI server will cancel PIM automatically and continuously to reduce its harmful impact on the site, recovering network performance and capacity.

In either case, the technician is armed with intelligence about PIM learned from the detection software tools, test equipment and the information gained from the installed ProteusCPRI. As data from PIM is collected over time the MNO gains more intelligence about network impacts that can help them avoid problems in the future, especially important as more spectrum is turned up and 5G becomes more widely deployed.

Summary

As wireless networks evolve to incorporate new technologies, upgraded equipment and additional bands to support the demands of 5G and its exciting and innovative applications, they are still prone to problems caused by PIM that have challenged networks for years. An example in this paper showed that PIM is costly for the MNO due to reduced traffic in addition to the expense dollars required to identify and resolve it. The new DETECT-RESTORE-SOLVE (DRS) Best Practices approach to PIM mitigation described here combines software to reliably Detect PIM on a timely basis, portable network equipment to Restore performance through monitoring-cancellation, and test equipment to quickly find the source and Solve the problem. Each of these three elements are effective alone, but the combined DRS solution reduces the time it takes to find and resolve PIM problems and eliminate the substantial and real cost those problems create.

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