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Improving wireless Networks Passive Intermodulation

Improving Wireless Networks

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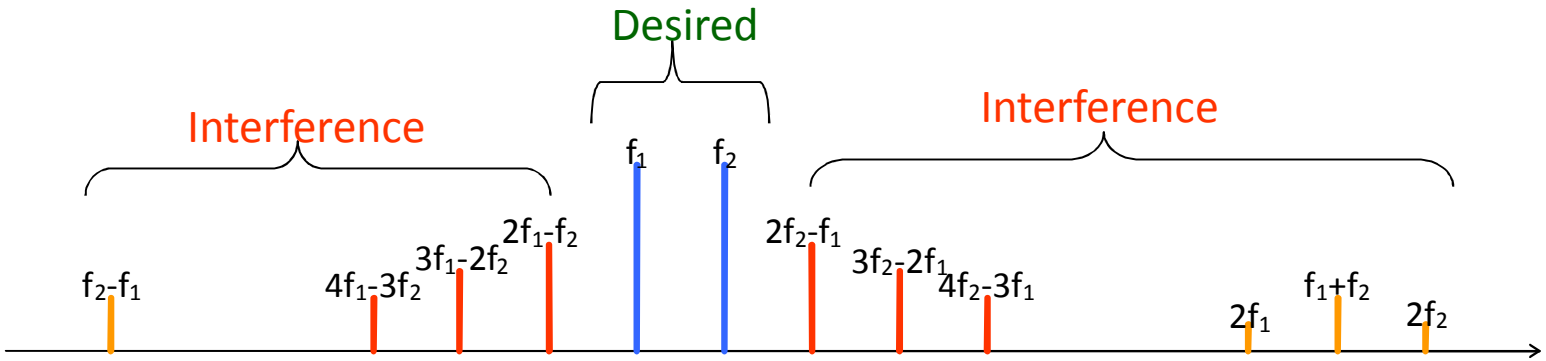
What is Passive Intermodulation (PIM)?

What is Passive Intermodulation (PIM) ?

PIM = Noise generated by the interaction between the multiple Tx signals and passive non-linear junctions in the RF path.



PIM generated products will affect received band (UL) by

Increasing the received Noise floor thus reducing base station sites coverage and capacity.

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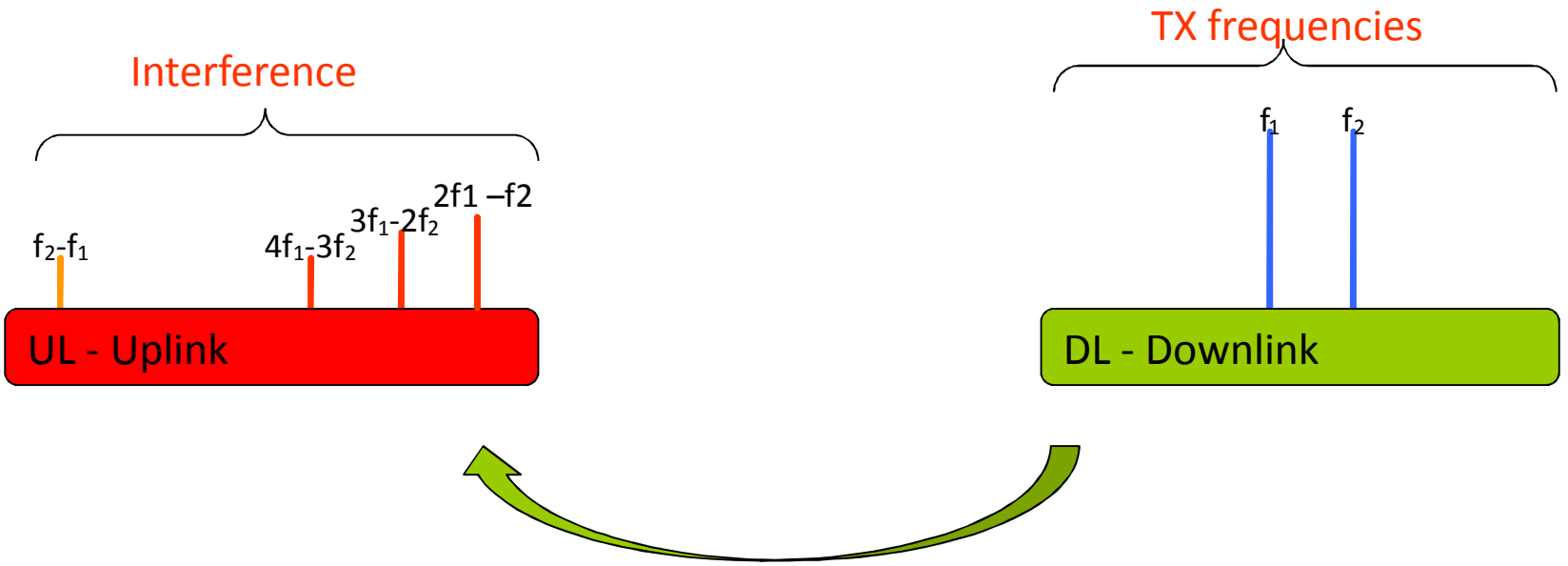
What is Passive Intermodulation (PIM) ?

For wireless operators



GSM, UMTS, LTE, CDMA, WCDMA

What is Passive Intermodulation (PIM) ?

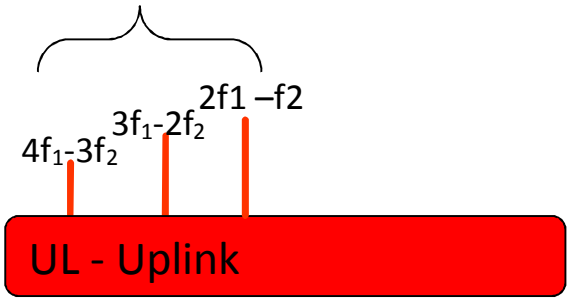
PIM depends on:

- Number of possible frequency combinations (more frequencies more possible combinations)
- The frequencies TX power (+ 1dBm Tx Power = + 2.5 to 3 dBm on PIM)

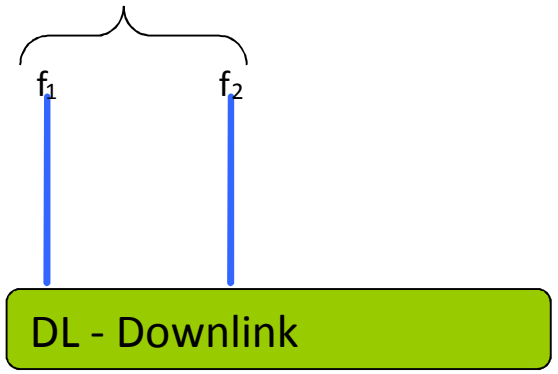
PIM is getting more complex with

GSM900 Example

RX operator 1

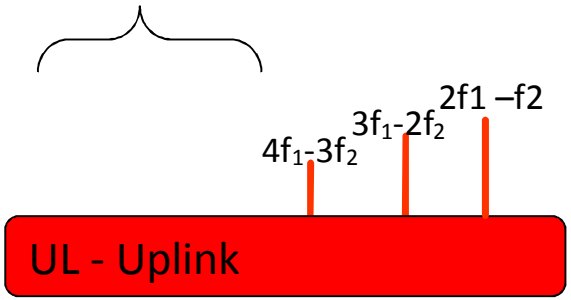


TX operator 1

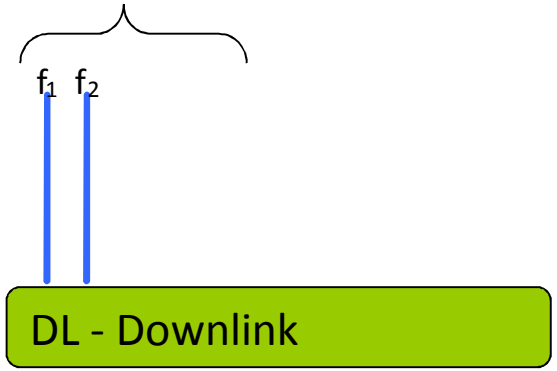


By changing the TX frequencies the IM products change

RX operator 1



TX operator 1



PIM is getting more complex with

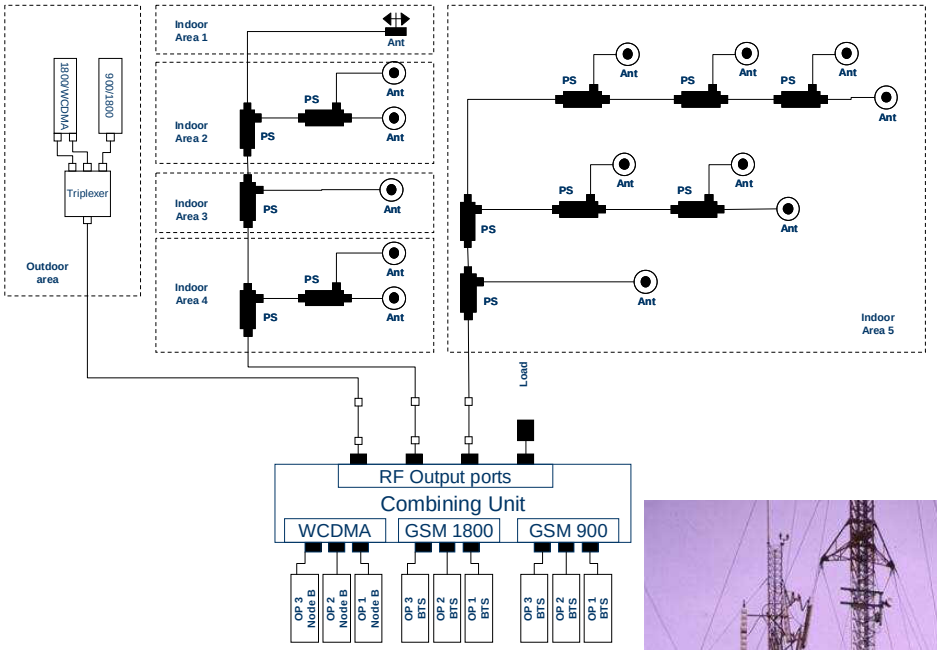
But now you have GSM900 with UMTS900 or LTE1800

Not a lot of space to change TX frequencies, a UMTS carrier that normally is 5 MHz or LTE 10 MHz carrier and more combination possibilities

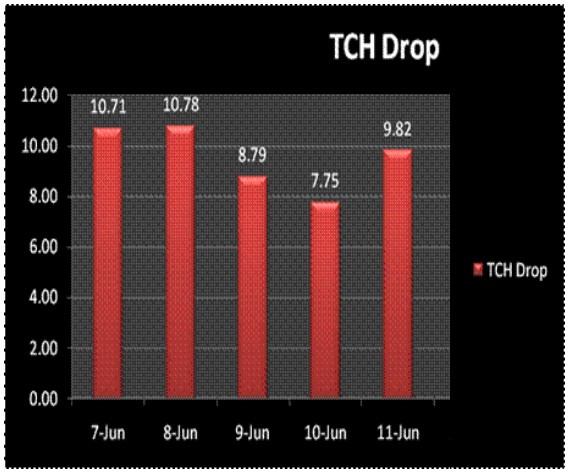
PIM is getting more complex with

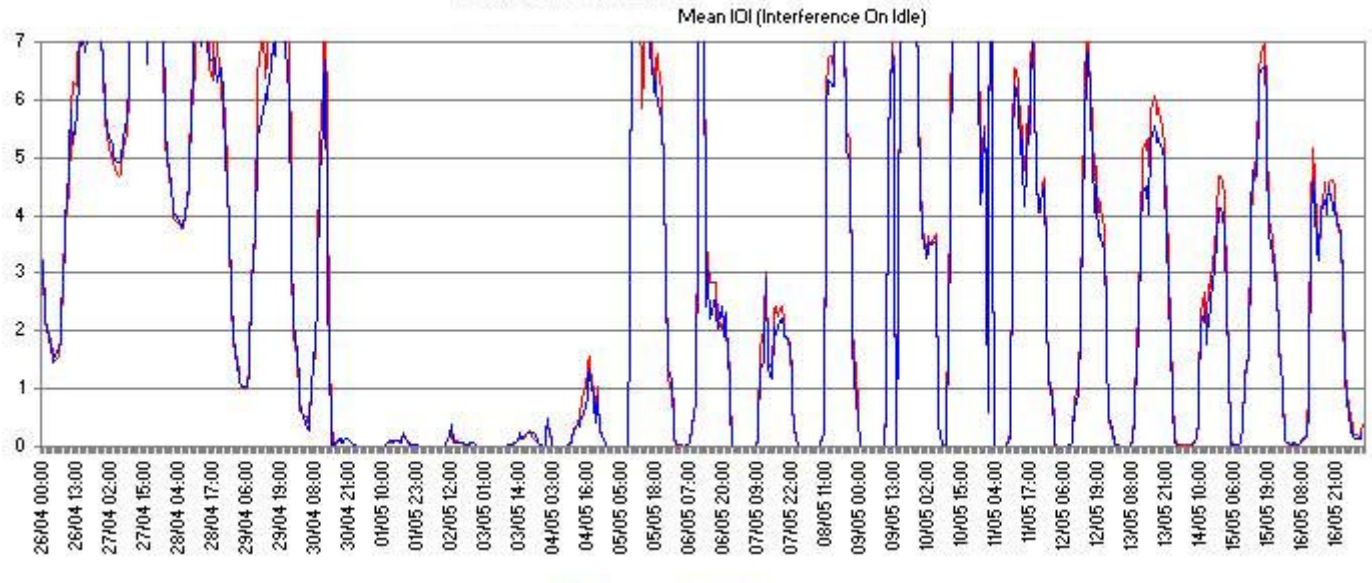
Networks evolution towards:

- Indoor or outdoor complex DAS systems (shared by several operators)
- Site sharing with multiple transmit carriers (same RF infrastructure for multiple operators)
- Multi-technology sites (GSM 900 MHz, GSM 1800 MHz, UMTS 2100, UMTS 900 MHz, CDMA 450, LTE800, LTE2600…)



How it appears on the Radio Access Network

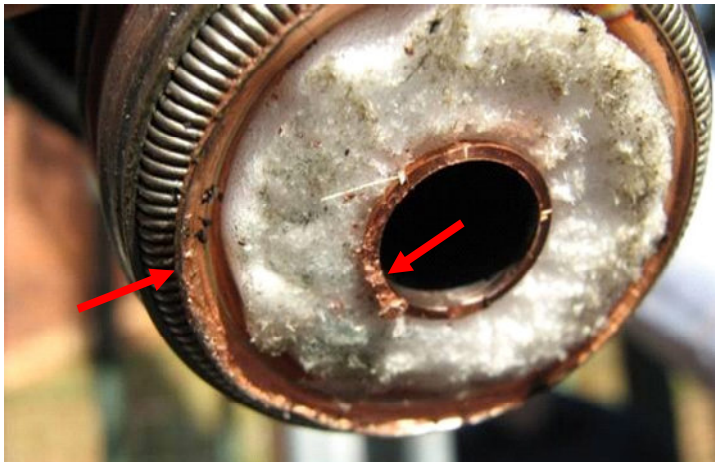




PIM Sources

Non-linear metal-to-metal contacts:

- Loose RF connectors.
- Poorly prepared RF cable terminations
- Improperly mated / misaligned parts
- Cracked / cold solder joints
- Loose mechanical fasteners (screws, rivets)



Traditional sweep (RL or DTF) testing many times does not identify these problems.

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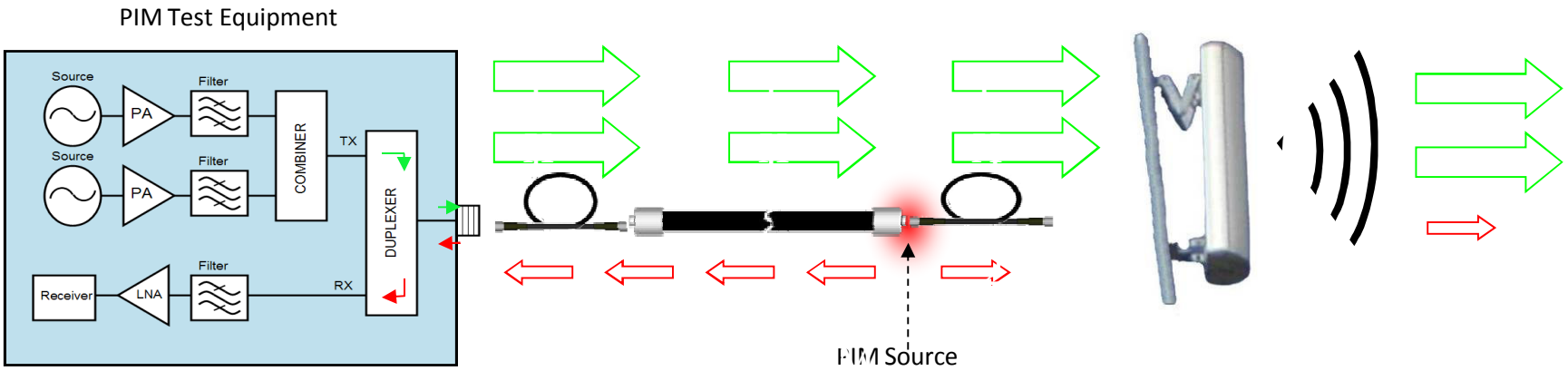
PIM test specification IEC 62037

- First edition of IEC 62037 was published on 9/16/1999. (>14 years ago!)
- Purpose:
  - To establish a standard test method for measuring Passive Intermodulation (PIM)
  - Provide a method to compare the PIM performance of different devices
- Key recommendations of the specification:
  - Third Order IM products typically represent the worst case condition of unwanted signals; therefore measuring IM3 characterizes the DUT
  - PIM comparisons should be done at the same power level.
  - 2x 20 W recommended for mobile communications systems.
  - Devices should be subjected to an “impact” or “movement” while PIM testing

How to test PIM?

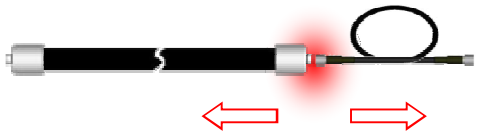


PIM Test equipment transmits 2 frequencies at high power into the system under test and measures the magnitude of the interference generated at the known IM3 frequency.

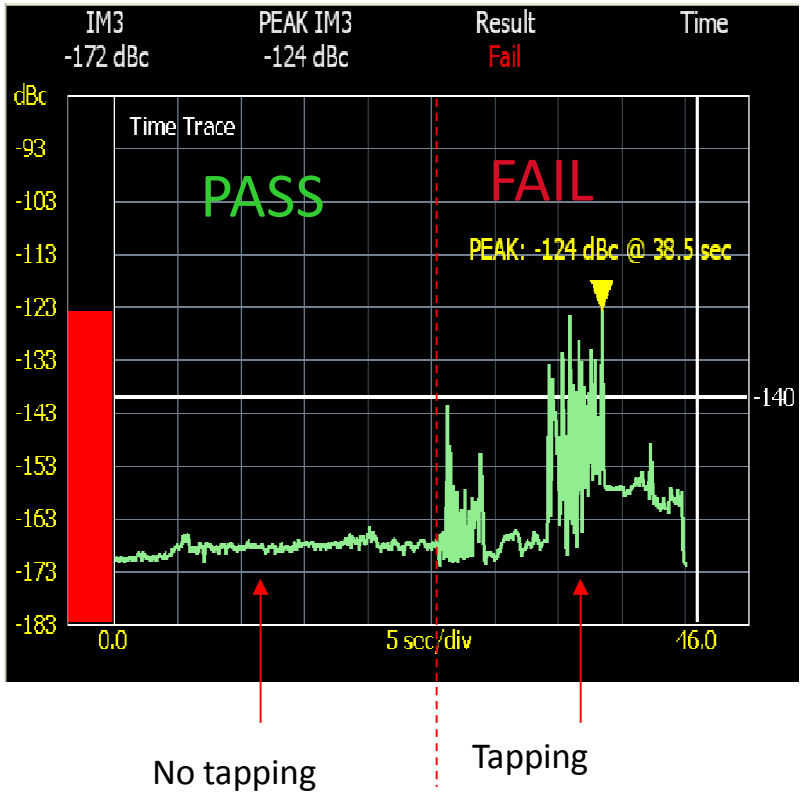
The fault location is found by “tapping” on interconnections and components (dynamic test) during the test looking for spikes in PIM magnitude.

PIM tests must be dynamic

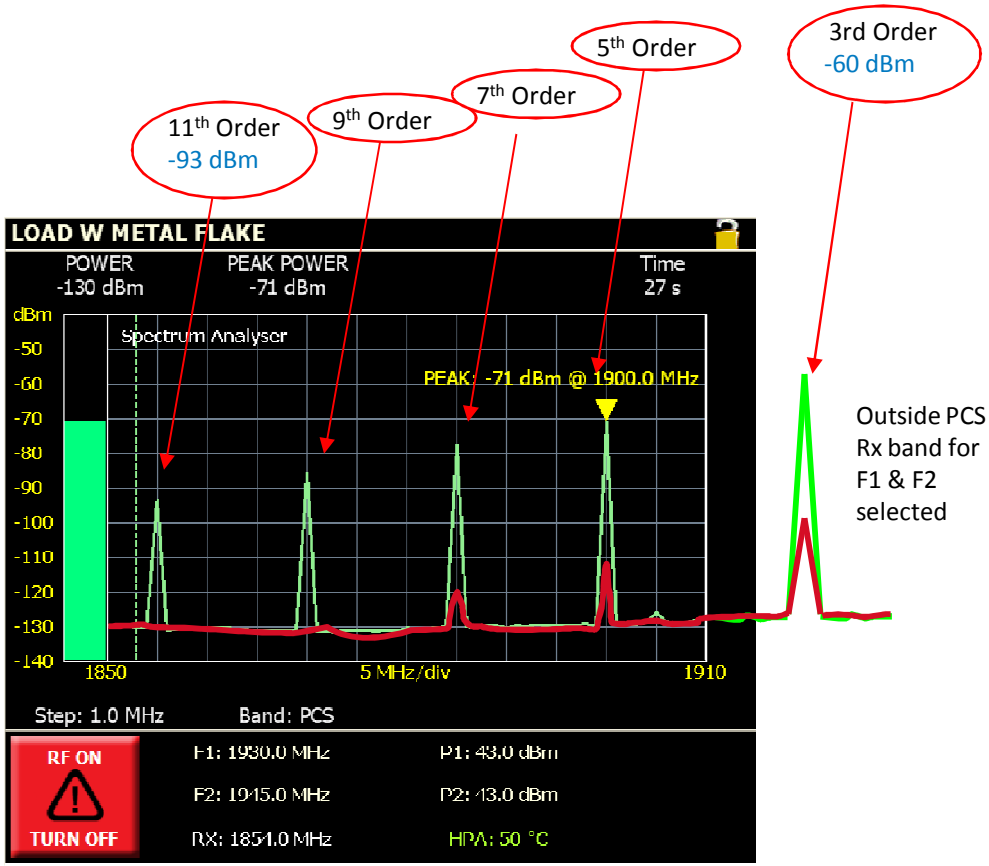
- IEC 62037 requires that devices be subjected to an “impact” or “movement” while PIM testing. Referred as “Dynamic” testing
- Loose mechanical contacts in the field may not generate PIM until subjected to a future environmental stress (thermal cycling, ice loading, wind loading, etc.)
- PIM level must stay below the specified maximum at all times during a dynamic test



Poor RF Connection



PIM Severity



Outside PCS Rx band for F1 & F2 selected

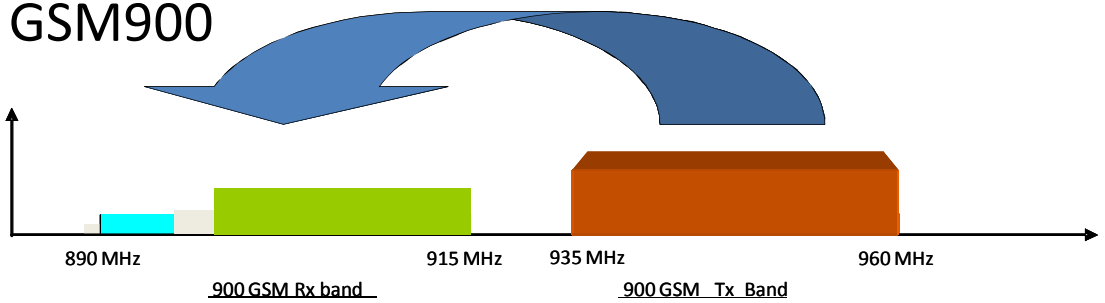
Spectrum Analyzer Mode

Metal flake

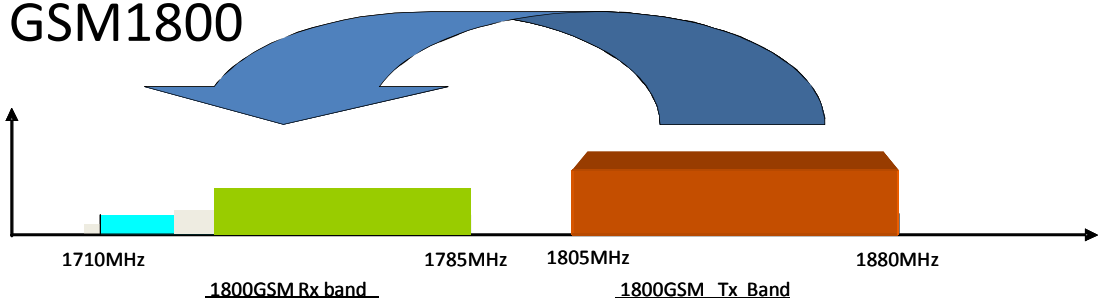
Repairing IM3 reduces ALL IM products.

Possible to have Same Band intermodulation issues

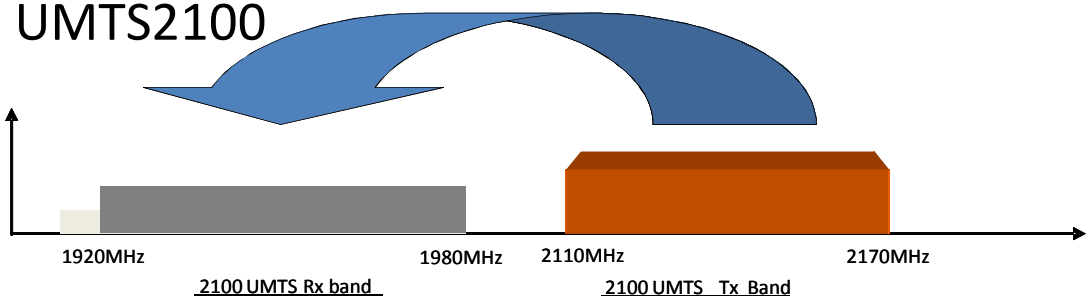
- GSM900



- GSM1800



- UMTS2100



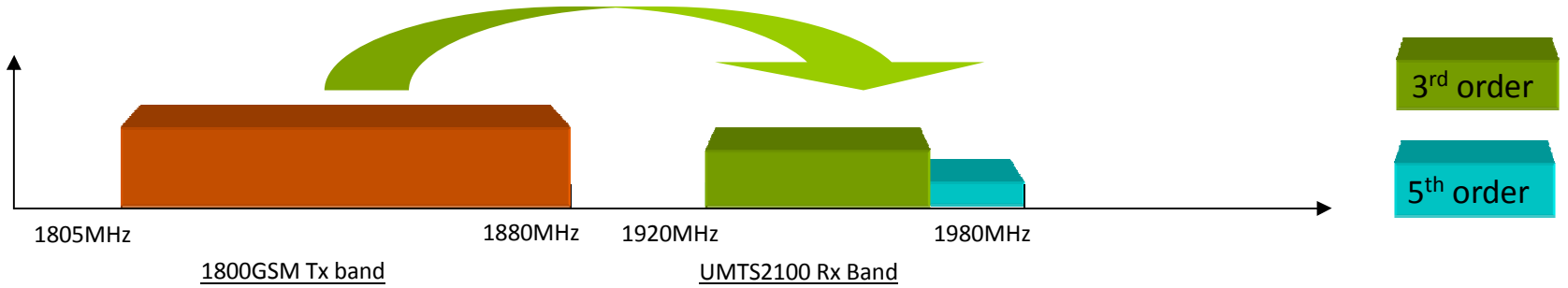
3rd order

5th order

7th order

Also, Cross Band intermodulation issues involving UMTS

- DCS1800 into UMTS2100



And with LTE there are multiple combinations nowadays

Where to look for PIM on statistics?

- Main search focus on:
  - General – CDR, CSR, CSSR

GSM

- GSM Mean interference on Idle (IOI)
- TCH Completion Rate and Drop %
- TRAFFIC RATE Erlangs
- TCH Assignment Rate
- SDCCH Assignment rate and drops
- HO Success Rate
- UL Quality
- Erlang Minutes Per Drop
- DROP_AFTER_TCH_ASSIGN
- SDCCH_RADIO_FAIL

UMTS

- CDR data and voice
- RRC Success rate%
- RAB Establishment Success %
- Voice Traffic Erl
- PS Traffic (Mb)
- Average Throughput
- RTWP
- RSSI

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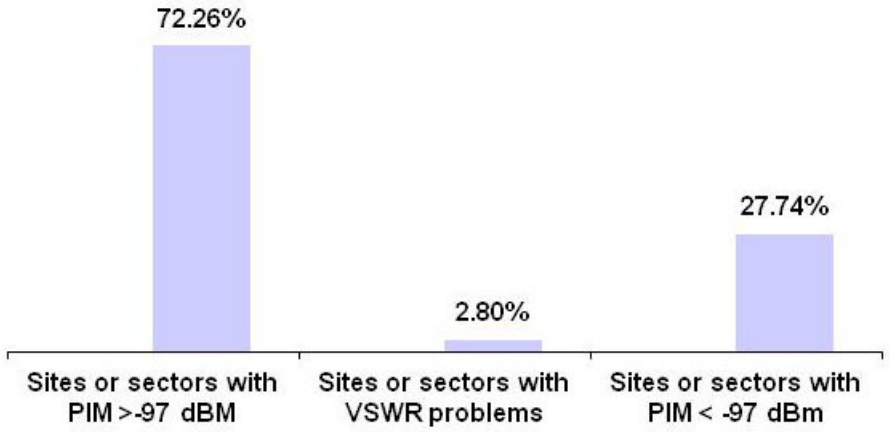
KAELUS field trial evaluation

PIM Survey in EMEA by KAELUS

KAELUS trials:

- >430 feeder lines surveyed.
- 26 Operators and OEMs, 17 countries
- Many PIM problems recorded
- Few VSWR problems found

The sites were originally commissioned with Sweep test equipment so it is no surprise that the VSWR results are good

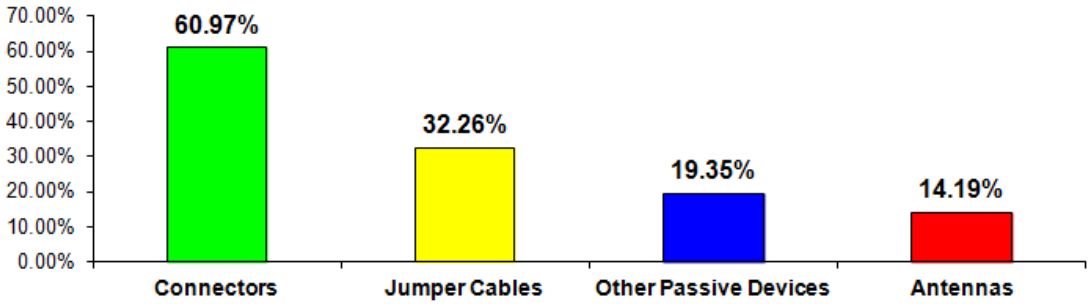


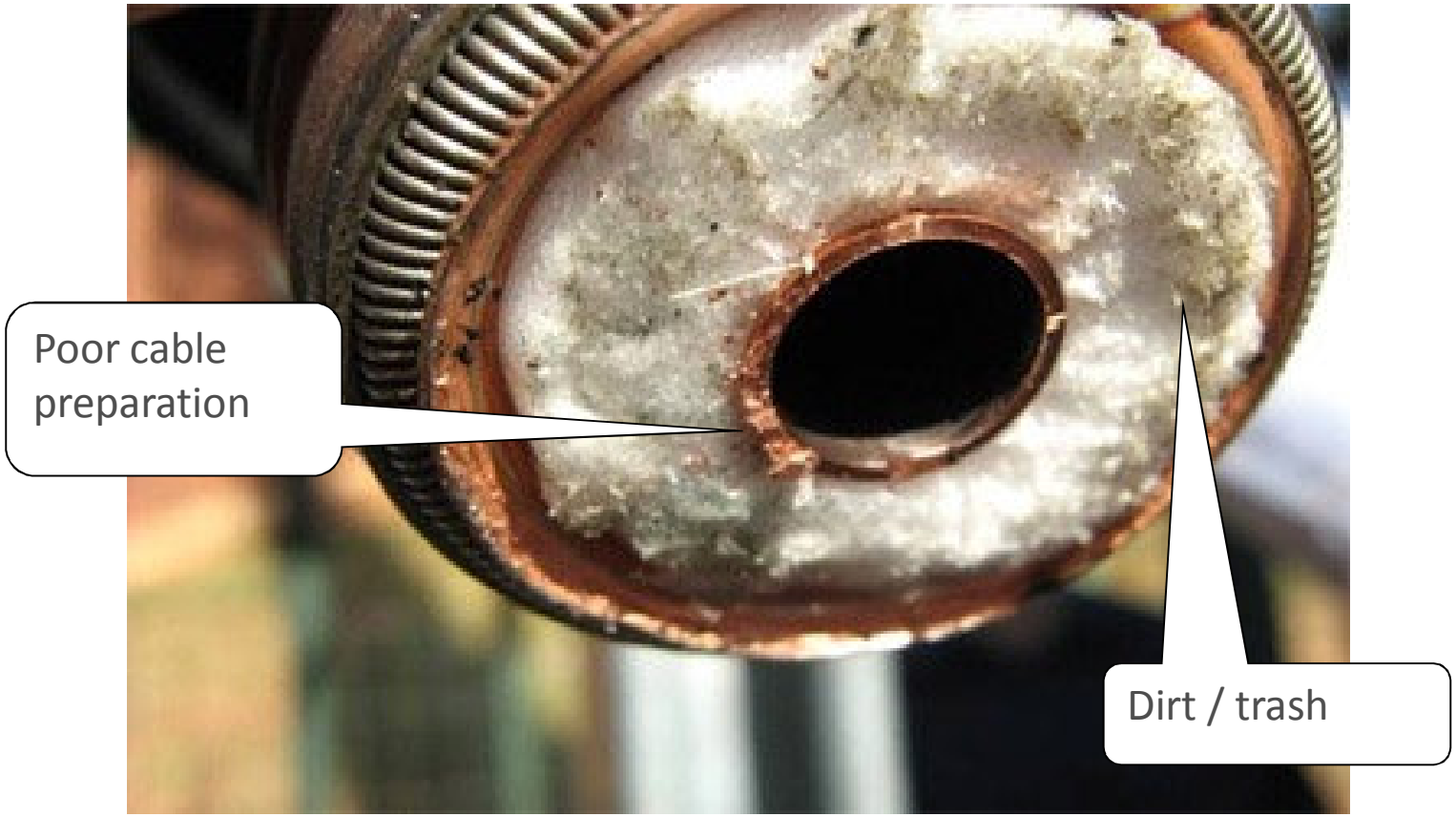
Comment on Statistics

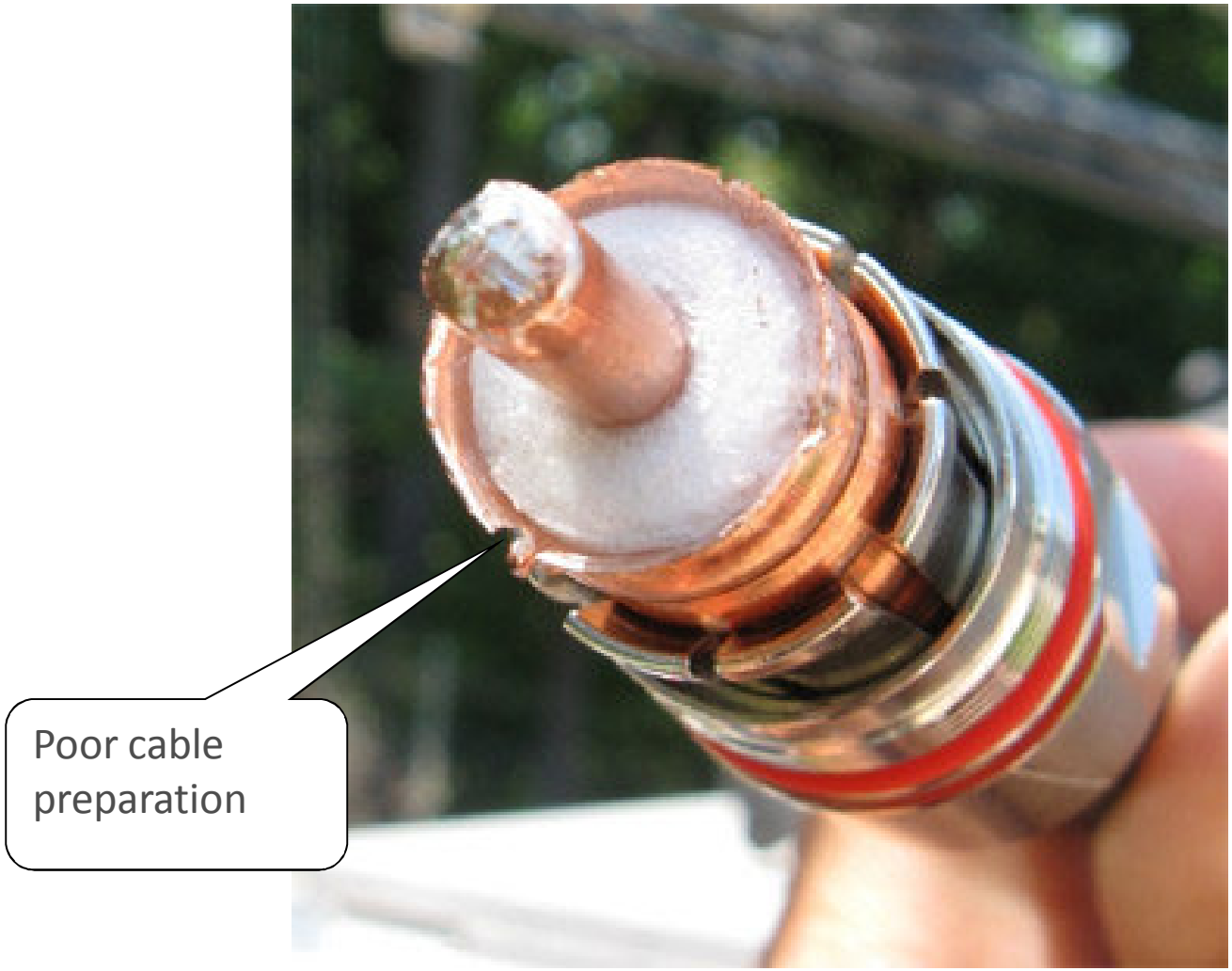
On the trials our customers select general bad performance sites to perform the PIM tests.

PIM Survey in EMEA by KAELUS

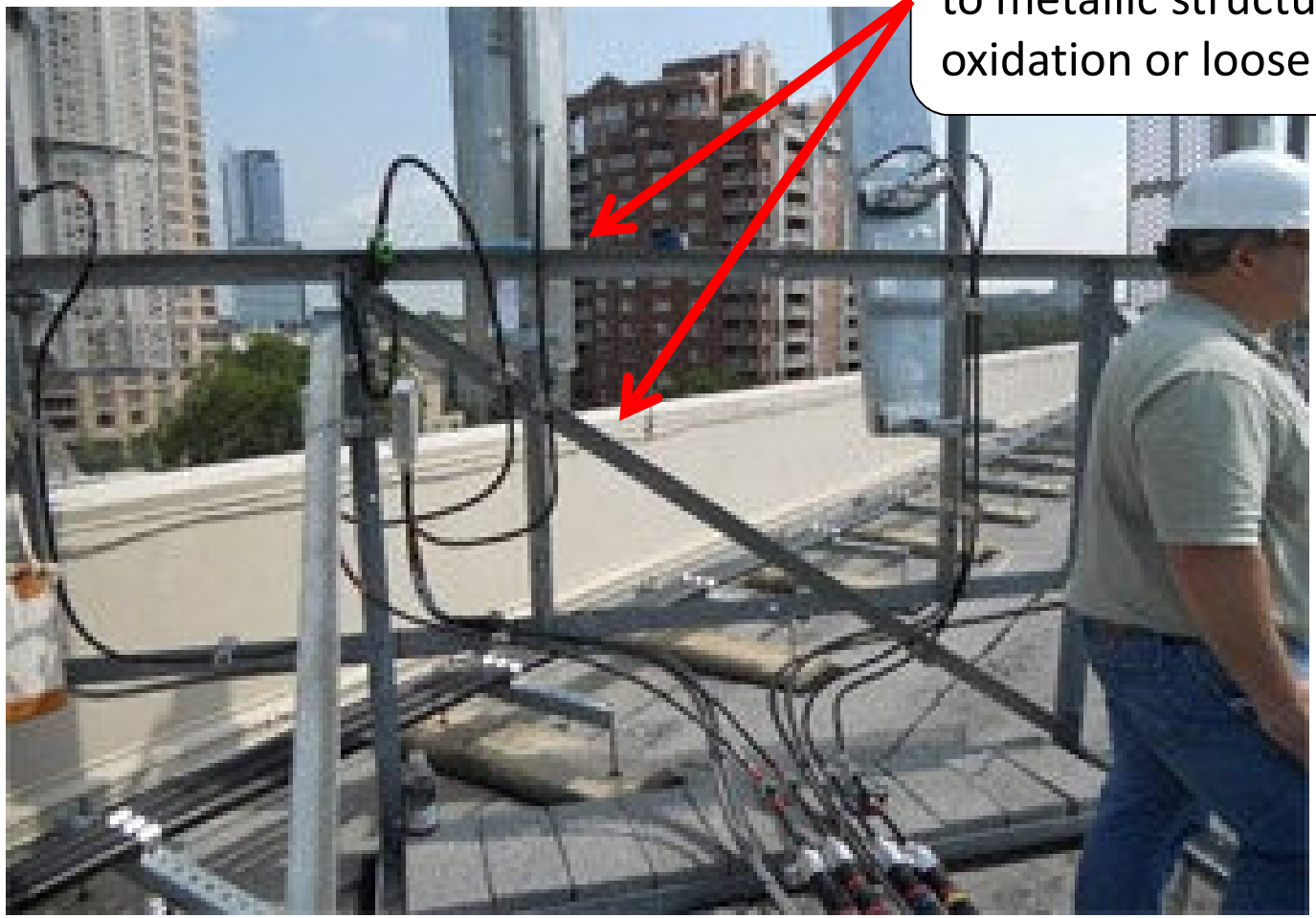
- The PIM defects found were primarily due to workmanship issues at the RF connections.
- Many lines had multiple defects
- *KPI improvements reported on the majority of sites that PIM was detected and repaired at site*




Poor cable preparation
Dirt / trash


Poor cable
preparation

Antennas closely pointing to metallic structures with oxidation or loose screws



KAELUS Case Studies

GSM 900 + GSM 1800 + UMTS 2100 Multi-operator DAS system

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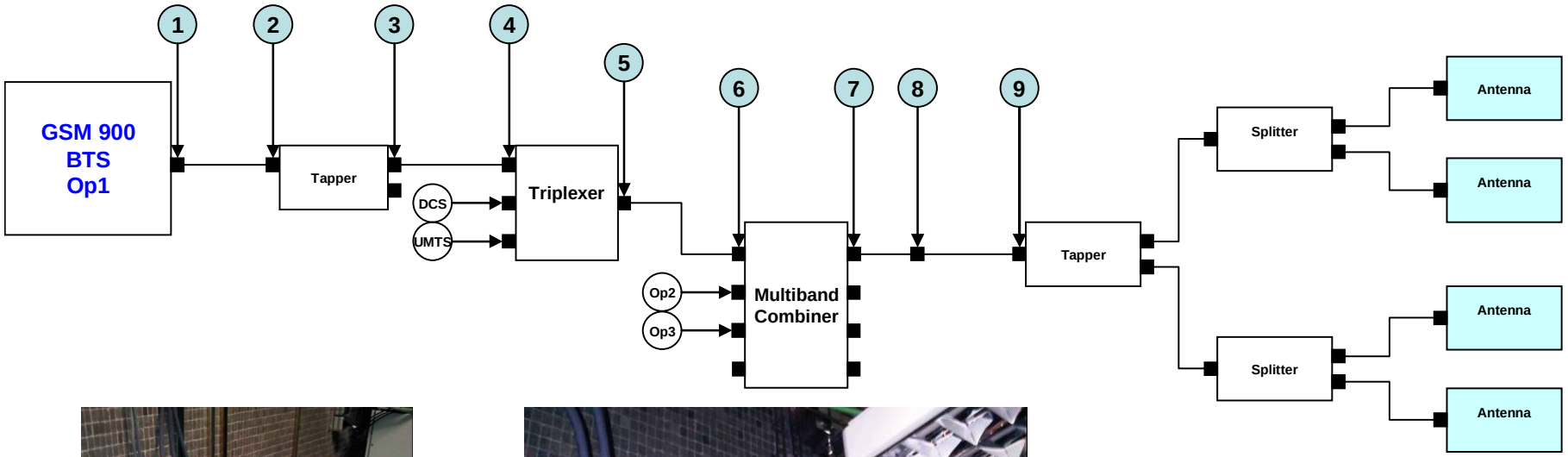
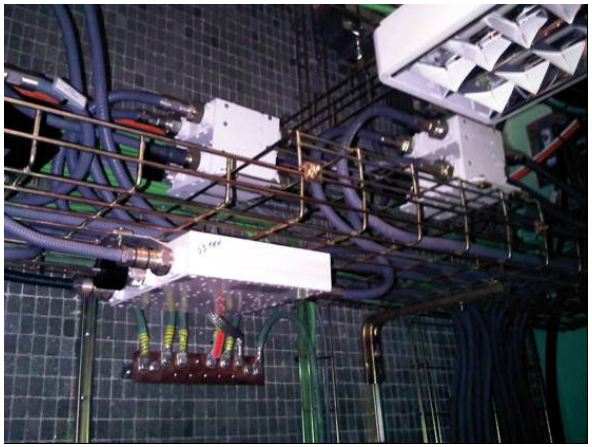
GSM 900 + GSM 1800 + UMTS 2100 Multi-operator DAS system





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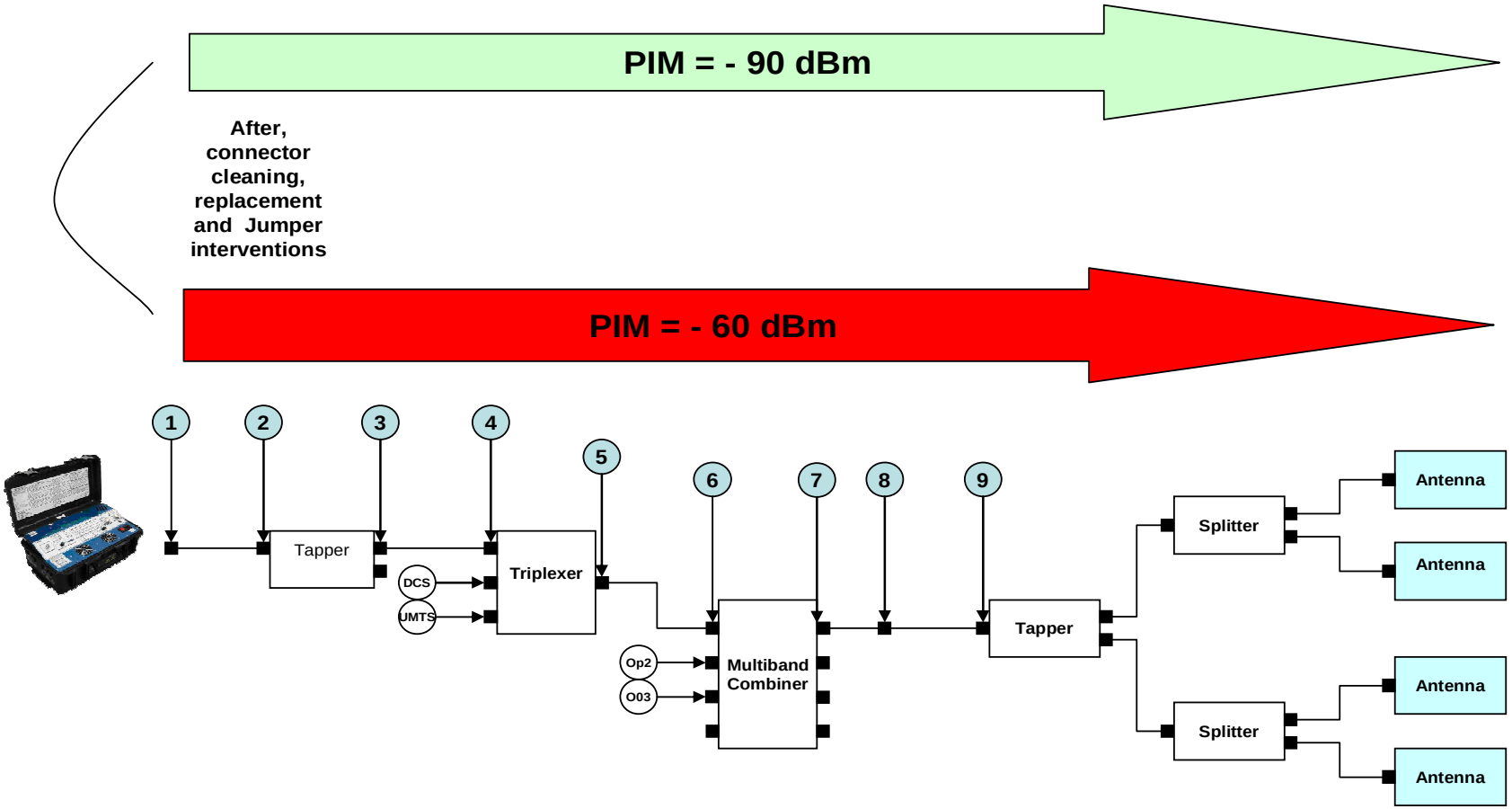
GSM 900 + GSM 1800 + UMTS 2100 Multi-operator DAS system



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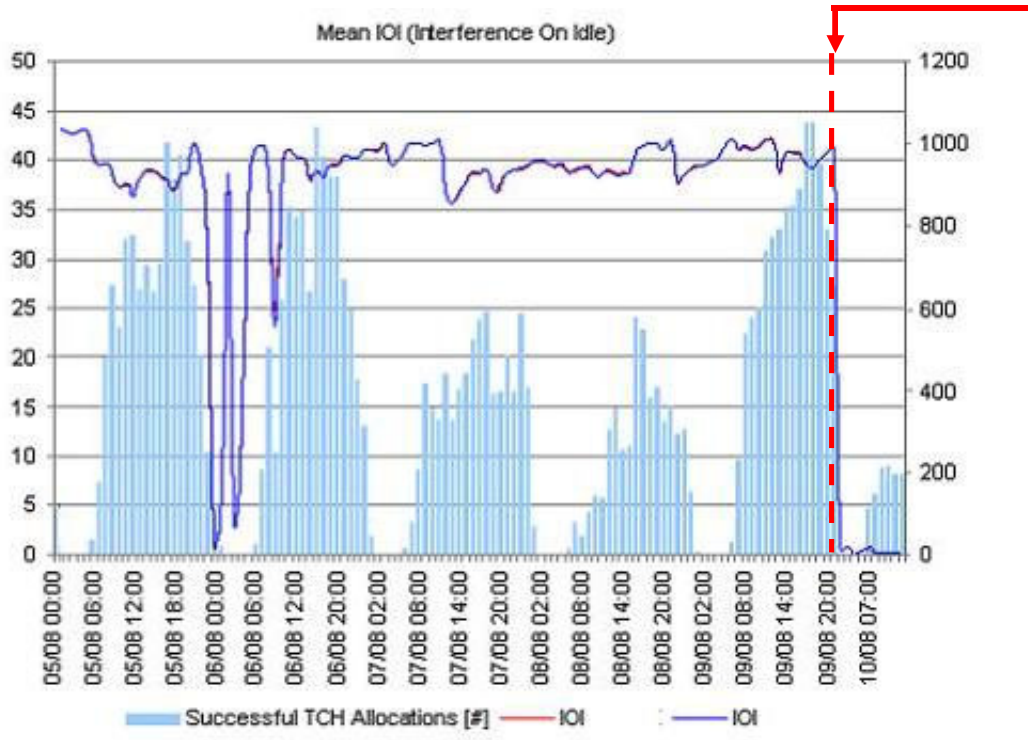
GSM 900 + GSM 1800 + UMTS 2100 Multi-operator DAS system



PIM detection and correction date

Connector problem

(node 8)

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UMTS2100 Rooftop Site

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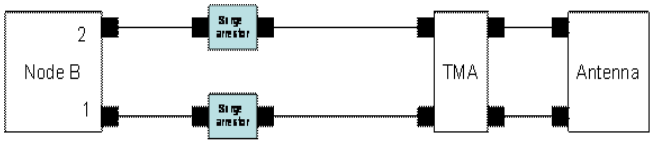
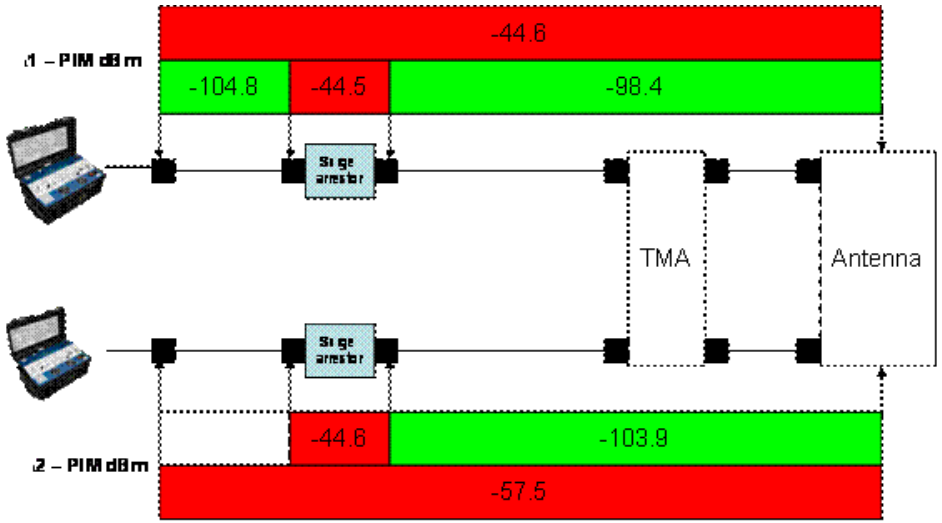
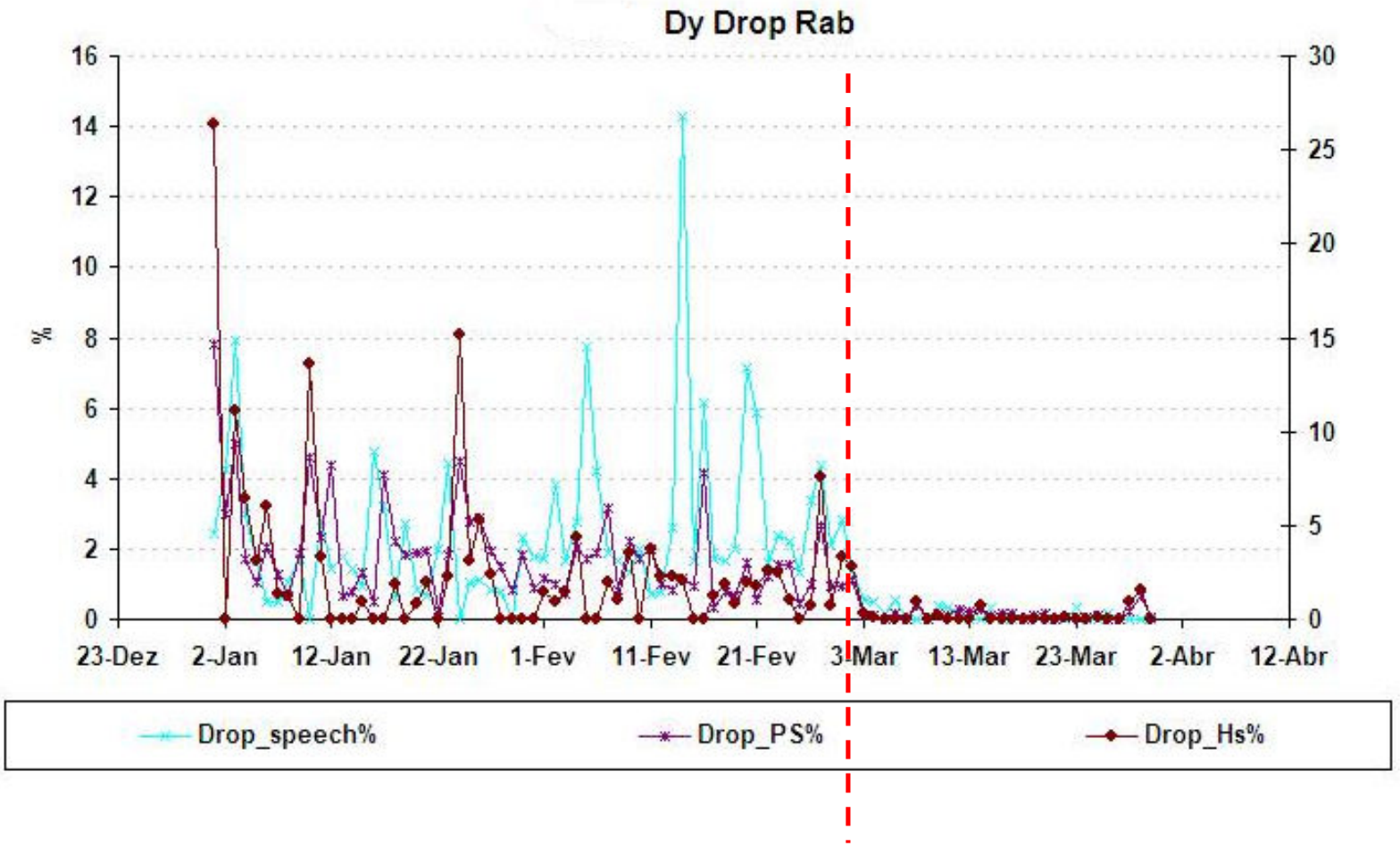
3G Rooftop
Urban dense site





Surge Arrestors were the source of PIM
After their replacement



After PIM changes

KAELUS PPIM Solutions

PIM testing is not new!

- Summitek Instruments has been producing “bench top” PIM test systems for more than a decade
- Summitek has delivered more than 800 BPIM systems worldwide
- These systems have been used by RF equipment manufacturers to reduce PIM in their component designs

What is relatively new is Portable PIM test equipment.

- "Portable" PIM test equipment enables system level testing to be conducted at the cell site.
- Kaleus has delivered more than 6000 systems worldwide.
- On site PIM testing reveals:
  - Installation workmanship issues
  - Component damaged during installation
  - Component damaged in transit

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PIM Test Equipment: iQA Series

- High Power – Premium
- Adjustable power (2 – 20W)
- Adjustable frequencies
- Rugged construction
- Integrated transit case
- Panel PC with touch screen interface, on-board reporting

MODELS |

	DESCRIPTION	TX RANGE	RX RANGE (PIM)	RTF MODULE #
iQA-0700LC	700MHz (low)	728-746MHz	698-716MHz	RTF-1000A
iQA-0700HC	700MHz (high)	728-757MHz	776-787MHz	RTF-1000A
iQA-0790C	LTE800	791-821MHz	832-862MHz	RTF-1000A
iQA-0850C	850MHz	869-894MHz	824-849MHz	RTF-1000A
iQA-0900C	GSM900	935-960MHz	890-915MHz	RTF-1000A
iQA-0901C	EGSM900	925-960MHz	880-915MHz	RTF-1000A
iQA-1800C	DCS1800	1805-1880MHz	1710-1785MHz	RTF-2000A
iQA-1921C	Dual band PCS/AWS	1930-1990MHz/2110-2155MHz	1710-1755MHz/1850-1910MHz	RTF-2000A
iQA-2101C	UMTS (3rd & 7th order)	2110-2170MHz	1920-2080MHz	RTF-2000A
iQA-2600C	2600LTE	2620-2690MHz	2500-2570MHz	RTF-2600A

PIM Test Equipment: iPA Series

- Adjustable power (+0.1 to 20W)
- Highly portable and ruggedized design – ideal for top-of-tower testing
- Includes tablet for safe, hands-free dynamic testing at the top of a tower
- Battery powered
- On board, touch screen interface available for local control
- Includes the Kaelus industry leading report generator

MODELS |

	DESCRIPTION	TX1 RANGE	TX2 RANGE	RX RANGE (PIM)	RTF MODULE *
iPA-0707A	700MHz LOW/HIGH	728-731.5MHz	741-764MHz	698-716MHz; 776-802MHz	RTF-1000A
iPA-0703A	APT700 LTE	758-763MHz	773-803MHz	703-750MHz	RTF-1000A
iPA-0790A	LTE 800	791-796MHz	808-821MHz	832-862MHz	RTF-1000A
iPA-0850A	850MHz	869MHz	879-894MHz	824-849MHz	RTF-1000A
iPA-0900A	GSM900	932.5-937.5MHz	949-960MHz	903-915MHz	RTF-1000A
iPA-0901A	EGSM900	925-935MHz	945-960MHz	880-915MHz	RTF-1000A
iPA-1800A	DCS1800	1805-1812MHz	1825-1880MHz	1710-1785MHz	RTF-2000A
iPA-1921A	Dual Band PCS/	1930-1950MHz	1970-1990MHz	1850-1910MHz	RTF-2000A
	AWS	1930-1950MHz	2110-2155MHz	1710-1755MHz	
iPA-2100A	UMTS (3rd & 7th)	2110-2130MHz	2150-2170MHz	1920-1980MHz; 2050-2090MHz	RTF-2000A
iPA-2600A	LTE 2600	2620-2630MHz	2650-2690MHz	2500-2570MHz	RTF-2600A

Thank you!

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