



800 MHz Reconfiguration Program: Intermodulation Interference Studies

This guidance provides TA guidelines for conducting Intermodulation (IM) interference studies for licensees participating in 800 MHz reconfiguration. IM studies identify certain specific forms of harmful interference produced by the RF environment that may prevent a licensee from achieving operational comparability post-reconfiguration.

These guidelines will be considered when the TA reviews Requests for Planning Funding (RFPF) and Frequency Reconfiguration Agreements (FRAs). This guidance intends to inform the reader what the TA expects to see regarding IM studies; it is not meant to be all-inclusive. These guidelines do not explicitly address other types of interference. Further, licensees are advised that, pursuant to the FCC's 800 MHz R&O, all costs related to reconfiguration, including those related to IM studies, must be agreed to by Sprint.

Background:

IM interference is created through non-linear interaction of two or more co-site transmit signals⁷ whose emitted frequencies combine to create significant harmful energy affecting a reconfiguring licensee's receiver or another licensee's receiver at the co-site. IM interference falls into three main categories. In decreasing order of significance and likelihood, they are:

1. *Receiver Intermodulation* – A non-linear mixing of external signals (and possibly internal local oscillator signals) inside the licensee's receiver;
2. *Transmitter Intermodulation* – A non-linear mixing of external and internal signals inside a co-site transmitter;
3. *Passive Intermodulation (PIM)* – A non-linear mixing in a passive device such as a loose connection, junction of dissimilar metals, etc. PIM sometimes occurs in a transmit antenna.

The magnitude of the problem depends on the number of proximate transmitters, their relative frequencies, the relative adjacency and positioning of antenna systems, the radiated power, filter and isolator arrangements, and the power spectral density of the interference with respect to the affected receivers.

For the purpose of this document, *harmful interference* is defined as interference that causes the base station receiver performance to drop below threshold when a simultaneous desired signal is 3 dB above receiver threshold. Receiver threshold is either 12 dB SINAD for analog FM receivers or a specified bit-error rate for digital receivers².

Circumstances Suggesting the Need for an IM Study:

1. A radio antenna location with two or more *co-site transmitters* operating on frequencies that are within a frequency band known to produce IM product frequencies at sufficient power that can substantially affect, and potentially impair, the reconfiguring licensee's fixed co-site receivers or other licensee's receivers;
2. The reconfiguring licensee's fixed receive antenna is proximate to a fixed transmitting antenna at a frequency likely to produce an IM product.³;

¹ **Co-Site Transmitter** – a transmitter whose proximity may cause directly, or indirectly, either radiated intermodulation interference (*transmitter intermodulation*) or receiver-induced intermodulation interference (*receiver intermodulation*) that creates harmful interference at co-site fixed receivers.

² See **TIA-603C** for more information on testing protocols.

³ Proximity is a function of power, distance, and propagation environment. E.g., 1 km at 1,000 ERPW or 316 meters at 100 ERPW for 3rd order IM products. These examples and their relationships are based on free space path loss where the field strength of a radiated signal varies proportionally with distance. Where there are obstructions, the path loss coefficient is expected to be higher, and thus more power and/or shorter distances would be necessary to cause harmful interference. The TA would expect to see no harmful IM products produced by sources of lesser power and or greater distances.

3. Landlords or site managers of shared transceiver sites may require an analysis of the IM environment as part of site agreements.

Unless one or more of the three circumstances listed above applies to an Incumbent, the TA believes IM studies are not required.

The Appropriate Level of IM Analyses

An IM analysis involves applying a model⁴ to an RF inventory at a co-site⁵. Such an IM analysis produces a candidate list of potential IM interference products and their respective *IM source frequencies*. Such a study is only as good as its underlying model and its input dataset. The licensee and/or selected consultant are expected to assemble input datasets from all reasonably available sources to maximize the usefulness of the model's results. If the model is capable of conducting a TNRD (Transmitter Noise Receiver Desensitization) analysis, that is integral and concurrent with IM analysis, a TNRD *co-analysis* will be allowed.

Where an existing IM study is being updated to reflect reconfiguration, the result of the update should enumerate any new potential IM products created by the reconfiguration. Site managers, the licensees, and/or consulting engineers should have the results of, and the underlying data for, previous IM studies required by contract(s). Under these circumstances, the TA expects the original IM study to be updated, reflecting the additions and/or deletions of the reconfiguring frequencies⁶ and the addition of other relevant information about the site. A *totally new* IM study would be acceptable if the licensee certifies that neither the site manager, nor the licensee, nor the engineers hired directly or indirectly by the site manager or the licensee, have IM Study data or the results of any pre-existing IM study for the site.

If a licensee has not conducted an IM study in the past, but meets the circumstantial criteria enumerated above, an IM study is appropriate. These studies should utilize all information available, including the FCC's ULS databases, to deduce potential *IM source frequencies* that might preclude the proper operation of a radio receiver at the *protected frequency(s)*⁷. If the outcome of such analyses indicates that the IM interference at the protected frequencies is likely negligible, then the IM analysis should be considered complete and a report should be issued.

Mitigation and Further Study Where Required

If the outcome of this study suggests there is significant potential for previously unmitigated IM interference at the protected frequency(s), then it would be proper to conduct further study and/or consider the deployment of conventional mitigation techniques to reduce the potential IM interference to levels comparable with those endured by the radio station before 800 MHz reconfiguration. Conventional mitigation techniques include filter and isolator placement strategies, appropriate antenna spacing or, where feasible, changing the proposed frequency.⁸

Further study includes assembling a more complete co-site inventory, including actual antenna system geometries, existing filter and isolator arrangements, a site visit(s) with spectrum analysis tools to verify the existence or non-existence of the relevant IM products suggested in the initial analysis. The goal is to separate the *actual* sources of significant IM interference from the *theoretical* interference sources and to deduce if they can be eliminated by practical and economical mitigation techniques.

⁴ **Model** – the set of assumptions, heuristics, theories, equations and necessary information that are used to detect IM source frequencies that can substantially impair a protected frequency. The model is typically embodied as an algorithmic and deterministic computer program.

⁵ **Co-Site Inventory** – an enumeration of RF elements and placement geometries that exist at a co-site that are relevant, useful, and appropriate to characterize the RF environment for a model. RF elements might include transmitters, combiners, isolators, filters, etc. Placement geometries might include vertical and horizontal antenna spacing, grounding arrangements, shielding arrangements, etc.

⁶ To facilitate the professional's evaluation of the IM environment, the TA will make available information regarding proposed replacement 800 MHz frequencies in the environment proximate to the reconfiguring licensee.

⁷ **Protected Frequencies** – Any validly licensed frequencies transmitted from or received at the site.

⁸ In most circumstances, changing proposed frequencies may be feasible with 1-120 Band and Expansion Band Reconfigurations, but not with NPSBAC frequencies.

After conducting further data gathering and modeling analysis, the IM study should be considered complete and a report should be issued.

Guidance for conducting IM Analyses

The licensee performing an IM study is encouraged to:

- Select a model that is accurate to the extent that generated results are empirically verifiable by similar models used by those practicing the art;
- To the greatest extent possible, leverage any accessible information that has been collected or analyzed about the site and protected frequencies. This includes, but is not limited to, computer model databases, co-site inventories (possibly produced during initial and/or subsequent build-out and/or design), reports from previous IM studies, etc.;
- Make reasonable efforts to exploit accessible and relevant IM studies being conducted by other co-site licensees to avoid duplication of effort and cost;
- Bound potential *Intermod Source Frequencies* being analyzed to those that are lower than three gigahertz (3.0 GHz);
- Ensure that, when using test equipment (e.g., service monitors, spectrum analyzers), that the test and measurement arrangements are thoroughly documented and the equipment is calibrated;
- Engage qualified and competent professionals and meet the criteria specified in the TA's *Reconfiguration Handbook*.

The TA recognizes that 800 MHz licensees represent a wide range of system configurations and circumstances. If a licensee believes a more extensive IM analysis is required than of those described above, or that the licensee's circumstances warrant an IM study even though they don't meet the TA's specified criteria, the licensee should submit an explanation of their particular circumstances and detailed MOP (Methods of Procedure) with their Cost Estimate. Licensees are especially advised to critique proposals to conduct IM studies at radio station locations with little to no complexity.

This document is the TA's guidance; Sprint may need additional information for specific negotiations.