

# Brief Note On Mobile Phone Measurements With Airplane Mode On/Off

D.J.Leith<sup>\*</sup>, D.Malone<sup>†</sup>

<sup>\*</sup>Trinity College Dublin, Ireland, <sup>†</sup>Maynooth University, Ireland

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## I. SUMMARY

This report describes the results of a brief investigation as to whether enabling airplane mode on a mobile phone disables all cellular transmissions. In summary, we found no evidence of cellular transmissions when airplane mode is on. The mobile handsets studied were a Pixel 8 (running GrapheneOS/Android 15), iPhone 15 (iOS 17.1.1), Samsung A23 (Android 13) and a Xiaomi Redmi Note 11 (Android 11).

## II. SETUP

Designing a measurement setup to test for handset cellular transmissions when airplane mode is on/off is surprisingly tricky. This is because to connect with a cellular network a mobile handset first scans for a cellular network signal, and if it finds none (or the signal level is too low) the handset will not make any cellular transmissions<sup>1</sup>. As a result, we observe no transmissions from a handset placed in a sealed anechoic chamber even when airplane mode is set off (and so cellular transmissions can certainly occur). To observe cellular transmissions by the handset, the cellular tower signal must be able to reach the handset.

One approach might be to place a cellular basestation alongside the handset within a sealed anechoic chamber. This is certainly feasible since software-defined radio basestations are available, but it would then be difficult to distinguish transmissions by the basestation from transmissions by the phone and so hard to reliably confirm whether the phone makes transmissions or not.

The setup we settled upon is to place the handset inside an anechoic chamber with the door left ajar, see Figure 1(a). This allows an attenuated cellular network signal to reach the handset. Since the signal path to the cell tower is weak, the handset compensates by transmitting at high power and so handset transmissions are easy to detect using a spectrum analyser. The primary disadvantage of this approach is that environmental transmissions (e.g. nearby handsets outside the chamber) can leak into the chamber, albeit with an attenuated power level. To compensate for this, we took measurements when the building containing the anechoic chamber was largely unused.

In summary, we placed the mobile handsets inside an anechoic chamber with the door left ajar, see Figure 1(a), and

<sup>1</sup>The first step in accessing the network in 3G, 4G and 5G is a cell search procedure, which is listen only.

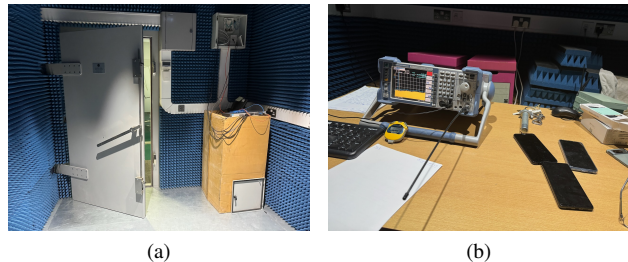


Fig. 1: Anechoic chamber used to take measurements. Note door left ajar to allow some cellular signal reception.

measured the environmental radio power using an Rhode & Schwarz FSL-6 spectrum analyzer, see Figure 1(b). The spectrum analyzer was configured to report the maximum observed power across the frequency range 500MHz to 3GHz using 3MHz bins (RBW 3MHz, VBW 10MHz). The handsets were placed close to the antenna during testing though the antenna used with the spectrum analyser has frequency dependent gain, and so the reported power levels are only relative. A period of approximately 5 minutes was used for each measurement.

Details of the handsets used are given in Table I.

On each mobile handset we disabled WiFi and Bluetooth in the phone settings. Starting with the handset powered off, we then powered each handset on with airplane set on and then again with airplane mode set off, while measuring the environmental radio power.

Handset	Software
Pixel 8	GrapheneOS/Android 15 build number 2025041100
iPhone 15	iOS 17.1.1
Samsung A23	Android 13 build number TP1A.220624.014.A236BXXU3CWC1
Xiaomi Redmi Note 11	Android 11 MUI 13.0.14.0 (RGKEUXM)

TABLE I: Handset details

## III. PUBLIC DOCUMENTATION OF AIRPLANE MODE

An Apple support page<sup>2</sup> states that “Turning on Airplane Mode turns off all radios except for Bluetooth”. We could not find any corresponding clear statement for Android.

<sup>2</sup><https://support.apple.com/en-us/108785>

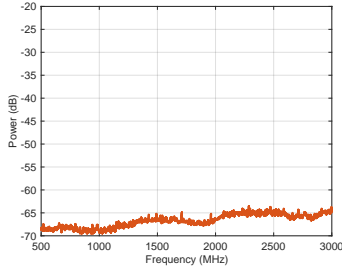


Fig. 2: Baseline radio power measured with all phones powered off.

#### IV. MEASUREMENTS

Figure 2 shows the baseline environmental radio power measured within the chamber when all mobile handsets were powered off. Figure 3 show the corresponding measurements for each of the mobile handsets with airplane mode on and off. It can be seen that with airplane mode on, the measured radio power remains similar to the baseline in Figure 2.

In contrast, when airplane mode is set off, substantial spikes in radio power are observed at several frequencies commonly used by cellular networks in Ireland as well as transmissions in the 2.4GHz band (recall WiFi and Bluetooth are disabled in the phone settings, so presumably<sup>3</sup> these are associated with cellular transmissions).

The airplane mode off measurements shown in Figure 3(b)-(d) for the Pixel 8, Samsung A23 and Xiaomi Redmi Note 11 are taken after the handset are already powered on. Figure 4 shows the corresponding measurements now including the time during which the phones are booting up after being powered on. It can be seen that in Figure 4 there are spikes in radio power which are not present in Figure 3(b)-(d) i.e. there appears to be handset radio activity during phone boot that stops once boot completes. For all three handsets, the largest radio power spike is in the 2.4GHz band and so may be associated with boot initialisation of WiFi/Bluetooth, although both are disabled in the phone settings as well as airplane mode being set on. This activity is consistently observed<sup>4</sup>. For the Samung A23 and Xiaomi Redmi Note 11 there is also a smaller radio power spike at 846MHz which we believe may be due to transient environmental noise (recall that the chamber door is intentionally left ajar).

#### V. DISCUSSIONS

The limitations of this study include:

- 1) We take measurements over a period of roughly 5 minutes. Intermittent cellular transmissions that are spaced at longer than 5 minute intervals would not be detected.

<sup>3</sup>Another possibility is that disabling WiFi/Bluetooth via settings might not be as complete as we think - for example, it might do the equivalent of "ifconfig en0 down" but maybe that doesn't turn the radio off and maybe management packets like Beacon Requests might still be sent.

<sup>4</sup>On the Pixel 8 handset the spike occurs a few seconds after the Graphe-neOS splash screen is displayed, so likely quite late in the boot process and perhaps an Android issue rather than a driver one.

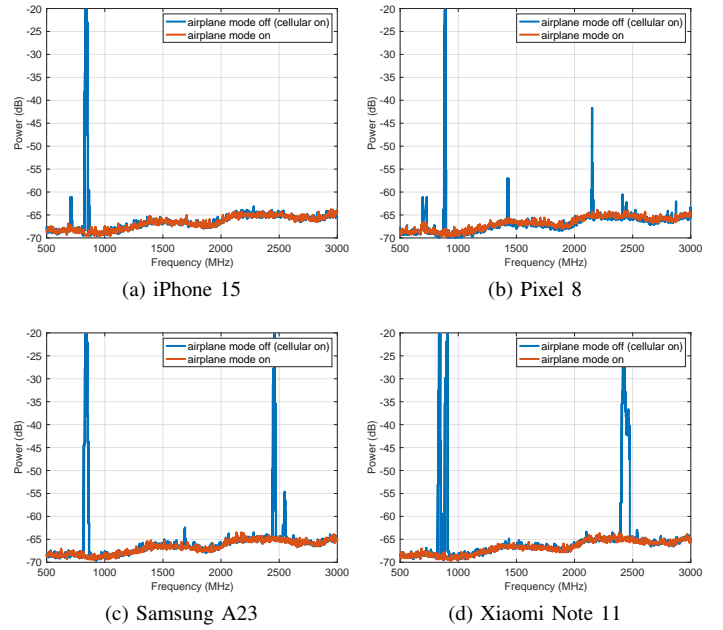


Fig. 3: Phones with/without airplane mode on (WiFi and Bluetooth are off).

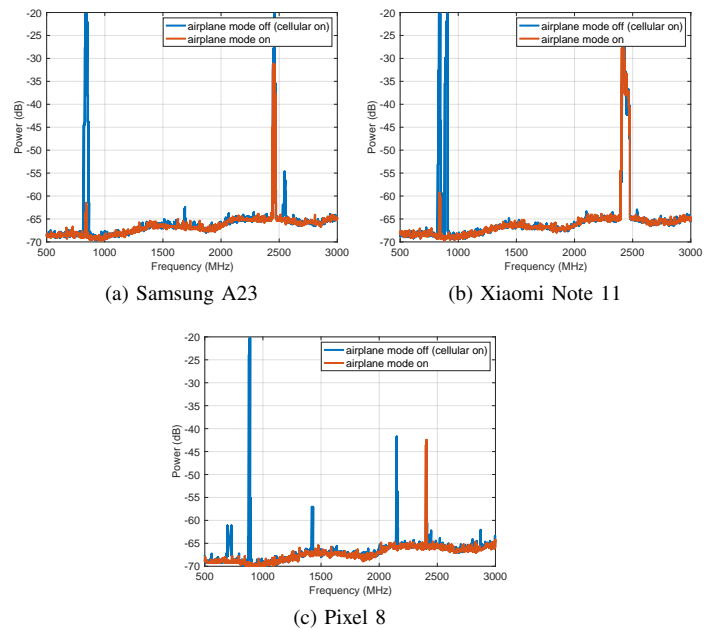


Fig. 4: Powering phones on with/without airplane mode on (WiFi and Bluetooth are off). Compare with Figure 3(b)-(d).

- 2) Event-driven transmissions (e.g reacting to the handset location or app usage) would not be detected since we only took measurements with the handset left idle.
- 3) Cellular transmissions with signal power below the baseline environmental level would not be detected. However, such weak signals would also be unlikely to reach the cell basestation with enough power to be decoded.