FM Radio in Smartphones: A Look Under the Hood

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Abstract - *The number of Smartphones sold in the U.S. that are equipped with FM radio receivers is increasing, but the devil is in the details. While virtually all smartphones have an FM receiver chip on board today, only some of them have FM reception fully enabled. There are also some smartphone models in which FM reception is enabled in other countries but not the U.S., and even some models in which FM is enabled by one or more U.S. carrier(s) but not others. In some of the latter cases, a software update or app download is all that is required to enable FM reception. This paper presents data on current penetration of smartphones in the U.S., with NAB Labs' analysis of these phones' FM reception capability or "readiness." The paper also presents findings of smartphone teardown analysis, detailing the actual communications chips and software used by popular smartphones.*

INTRODUCTION

For many Americans, the smartphone is a vital piece of everyday technology. But many smartphones in the United States are missing a feature that exists more widely elsewhere, and that would have positive value for American consumers, wireless carriers, and broadcasters. This missing component in many U.S smartphones is a fully enabled FM radio receiver.

Some may question how all three of the nonaligned sectors mentioned above can benefit from what is considered a mature or relatively "low-tech" smartphone feature. For consumers, the advantages are numerous:

- Listening to FM radio provides as much as a six-fold battery life extension over online streaming audio services. [1]
- FM radio listening has no impact on users' data plans, whereas streaming 2 hours of online radio services per day can use over 3.5 gigabytes (GB) of data each month. [2]
- Terrestrial radio offers consumers instant audio access at the push of a single button, as well as robust service nationwide, with emergency alerting and other critical information delivered in a timely and dependable fashion.

Benefits also extend to wireless carriers, which via customers' usage of FM receivers can offload redundantly provided streaming data, thereby conserving valuable bandwidth for other uses. FM radio in smartphones also provides carriers with more emergency alerting options at no incremental cost to the carrier. Wireless carriers—along with radio stations—can also benefit from new revenues derived from *hybrid radio* services.

For broadcasters the benefits are obvious. Over-the-air (OTA) radio services will return to handheld mobile platforms—an area from which broadcasters have largely been absent since the transistor radio and the Walkman®.

Although this marriage of mobile and OTA would seem to be a general benefit, challenges to its broad acceptance arise from smartphone manufacturers, wireless carriers, and lack of consumer awareness. While the availability of FM-capable smartphones sold in the United States has increased over the last several years, most U.S. smartphones are still unable to play FM radio, though virtually all of them possess the FM receiver chip that could provide this capability [3]. This paper will analyze the current state of FM radio reception capability in smartphones, discuss the variations in deployment of these systems (both domestically and internationally), take a deeper look at the hardware used for FM receivers in smartphones, and propose next steps that broadcasters can take to promote greater accessibility of FM radio in U.S. smartphones.

U.S. SALES DATA

To provide some context, the following data indicates the relative state of smartphones equipped and not equipped with FM radio reception capability, based on the latest NAB Labs research.

Figure 1 shows the breakdown of this capability among the top-selling[1] smartphones in the U.S. during the first three quarters of 2014 (the latest period for which data is currently available). It indicates that approximately 1 in 5 smartphones sold during this period had FM reception capability enabled out of the box by at least one U.S. carrier, and another 1 in 10 had the capability installed—and operating in other regions—but disabled by the U.S. carrier. It also shows that approximately 2 in 3 phones have FM receiver hardware on board, but it is not utilized by the manufacturer, and that among those phones, 2 out of every 3 are Apple *iPhones*.

[1] NAB Labs analyzes the top 70% of smartphone models by sales volume in each calendar quarter. This usually equates to 20-25 products. The distribution of smartphones by product has a highly "long-tail" characteristic. Beyond these top sellers, individual market shares of remaining products are each negligibly small, and therefore are not worthy of analysis, since results would not significantly change data trends shown.

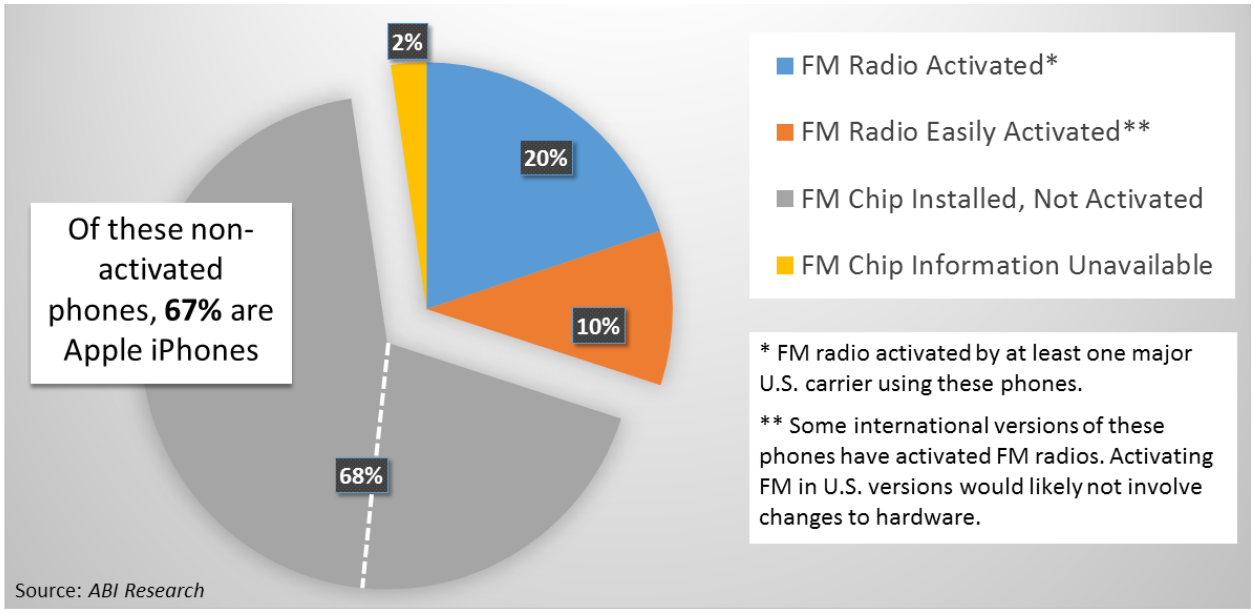

FIGURE 1: FM RADIO CAPABILITY OF U.S. TOP-SELLING SMARTPHONES (IN % OF TOTAL SOLD), JANUARY – SEPTEMBER 2014

Figure 2 shows the U.S. sales of smartphones with FM reception capability activated by at least one U.S. carrier, quarterly over the most recent two-year period. Although as Figure 1 shows, only a minority of smartphones sold in the U.S. have such capability, Figure 2 indicates that the trend is decidedly positive, countering the position taken by some in the wireless industry that consumers do not want FM capability in their devices. Figure 2 also provides a dramatic illustration of "the Sprint effect," given the boost in FM-enabled smartphone sales that coincides with the agreement between Sprint and broadcasters to broadly enable FM radio capability across their line of smartphone offerings.

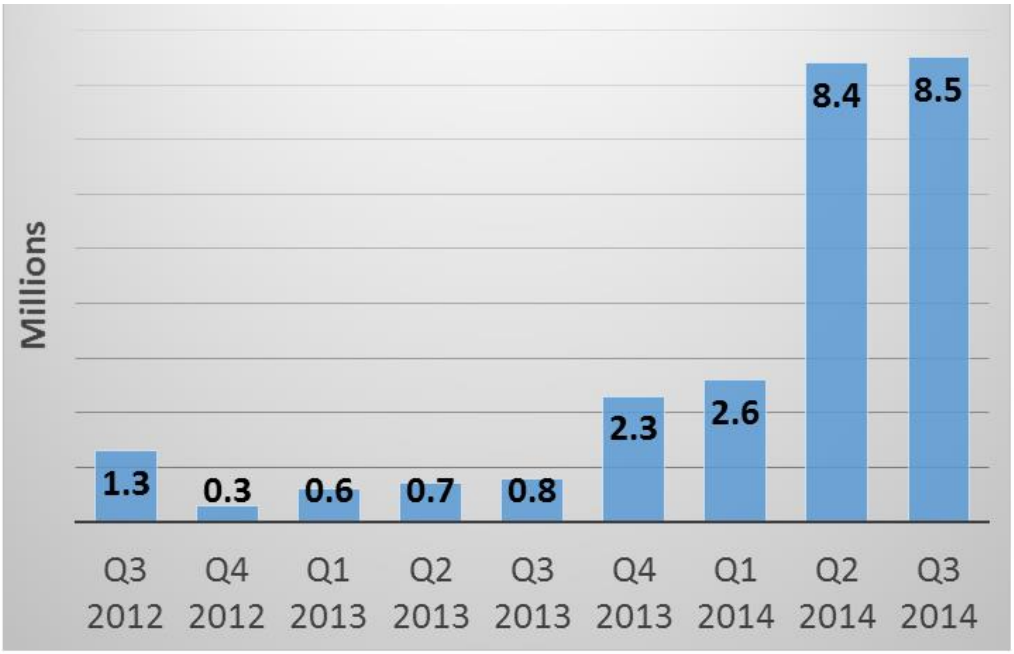

FIGURE 2: LATEST AVAILABLE DATA ON SMARTPHONES SOLD IN U.S. WITH FM RADIO ACTIVATED BY AT LEAST ONE U.S. WIRELESS CARRIER (SOURCES: *STRATEGY ANALYTICS* AND *ABI RESEARCH*)

A Hierarchy of Implementations

While virtually all smartphones sold in the United States are equipped with FM receiver hardware, or an "FM chip," nuanced differences separate those phones capable of playing FM radio directly out of the box from those that cannot. Our analysis has generated a classification hierarchy of such capabilities, which is presented below. Each successive class encompasses the characteristics of the classes beneath it.

I. Class 1: FM Receiver Hardware on Board

Class 1 smartphones are equipped with FM receiver hardware, but are not equipped to utilize this hardware for FM reception by the user. Converting this class of smartphone to enable FM radio reception is generally not possible by the user.

II. Class 2: FM Receiver Hardware on Board and Connected

Class 2 smartphones are characterized by operative FM receiver hardware. In these cases the "FM chip" is enabled, with the receiver's RF input connected to an embedded antenna or an antenna connector (i.e., headphone jack), and the FM receiver's demodulated output is connected to the phone's multimedia processing (feeding it analog stereo audio and, in some cases, RDS text data).

While FM radio reception is hypothetically possible on these devices, in Class 2 smartphones either the phone manufacturer or the wireless carrier chooses to not expose this capability to the end user. This implies that some necessary part(s) of the software stack on the phone is purposefully omitted (e.g., an FM tuner-control user interface [UI]), such that the user is unaware and/or unable to utilize the FM receiver capability provided on the phone.

In a few cases, the missing software elements can be downloaded by the user, and the FM capability is then enabled. An example of this is the HTC *One M8* as provided by Verizon Wireless, in which the otherwise functional FM receiver has no associated user interface ("app") preloaded; thus the FM reception capability of the phone is disabled, and the user is unaware that the phone has such capability. All other required software for FM reception is included in the phone, however (as it is on all versions of this phone worldwide, including as delivered by other U.S. wireless carriers), so if the consumer downloads the *NextRadio* app (see below) from an Android store and installs it on the phone, the FM receiver on the phone will be fully enabled. Of course, the user would have to be somehow advised that this process was possible.

In other cases, the manufacturer can provide a software update to existing phones that enables FM reception capability that was not possible on the phone as delivered out-of-the-box. An example of this is the Nokia *Lumia 520/820/920* smartphone line, which was originally shipped without FM receiver capability enabled, but an update to the Windows Phone 8 operating system used on the phones subsequently added the feature.

III. Class 3: UI Exposed

In Class 3 phones, a UI controlling the FM receiver is exposed, meaning that consumers have access to a native FM radio application directly from the box. The capability provides simple, conventional FM tuning and listening, in some cases with elements of a station's RDS data also presented on screen. FM hybrid capability is not enabled.

In some cases, these phones are capable of being upgraded to a Class 4 phone (see below) by the end user. An example of this is the HTC *One M8* as provided by AT&T Wireless. The phone is preloaded with a native, basic FM tuner control app, but the user can download the *NextRadio* app to add hybrid FM capability to the device.

IV. Class 4: Hybrid FM Enabled

Class 4 smartphones have hybrid FM radio functionality enabled out of the box. In the U.S., at this writing, Sprint is the only carrier to offer this class of phones. Hybrid FM radio capability is enabled via preloading of the *NextRadio* app on these phones, which include a variety of Android devices. The hybrid radio feature allows audio to be transmitted to the phone via terrestrial FM radio, while enhancements and other information, such as album art and interactive advertisements, are received through the smartphone's wireless data connection. Table 1 summarizes the classifications detailed above.

Class	Description	Examples
1	FM receiver hardware ("FM chip") onboard but not wired to function, and/or required software stack not installed	Apple iPhones; Samsung Galaxy S4; Samsung Galaxy S5 (AT&T, T-Mobile, Verizon)
2	FM chip onboard with RF input connected to antenna (typically headphone jack) and audio (and perhaps RDS data) output connected, but no UI exposed	HTC One M8 (Verizon)
3	FM chip onboard, connected, and FM user interface exposed	HTC One M8 (AT&T); Samsung Galaxy S3 (international)
4	FM chip onboard, connected, UI exposed, and hybrid FM software stack installed	HTC One M8 (Sprint); Samsung Galaxy S5 (Sprint)

TABLE 1 - SMARTPHONE FM RADIO IMPLEMENTATION CLASSIFICATIONS

DIFFERENTIAL DEPLOYMENT

As Table 1 shows, the deployment of these classifications of FM chips varies both on an international and national scale. While it is difficult to say exactly why differential deployment exists, the phenomenon has become more prominent over the last few years.

I. U.S. vs. International Deployments

Prior to the Sprint/NextRadio agreement, most popular smartphones sold in the U.S. did not come equipped with FM radio, whereas their international counterparts did include FM reception capability. For example, one of the most popular phones of 2012, the Samsung *Galaxy S3*, is had its FM reception capability disabled in all units sold in the U.S., although elsewhere the phone's FM reception worked out of the box. Numerous top-selling LG smartphones also had their FM radios enabled internationally, but disabled in the U.S.

In cases such as these, it is possible to conclude that the reason FM radio capability was disabled in U.S. versions of the product resulted from an active choice by the wireless carrier or manufacturer to do so.

II. Differences Among U.S. Carriers

More recently, in the wake of the Sprint/NextRadio deal, there has been a greater divergence in FM capability on the same phones provided by different wireless carriers *within the U.S.* A good example cited in the previous section is the Samsung *Galaxy* S5, which Sprint delivers as a Class 4 device, while other U.S. carriers deliver it as a Class 1 phone.

Another current example of differential deployment in the United States cited above is the HTC *One M8*. HTC enables FM reception capability in all versions of the phone worldwide, but in the U.S., Sprint delivers it as a Class 4 device, AT&T delivers it as a Class 3, and Verizon delivers it as a class 2. All versions are user upgradable to Class 4, but in the case of Verizon, the product's user guide does not list FM radio as an available feature.

III. The Sprint Deal – Enabling Hybrid FM

The landmark agreement in 2013 among radio broadcasters, *NextRadio* and Sprint has opened the door to broad deployment of FM hybrid radio, and made the inclusion of FM receivers more appealing to manufacturers and carriers.

A DEEPER DIVE

I. Teardowns – The "Connectivity Chip"

Although we use the term "FM chip" to refer to FM receiver hardware in smartphones, this chip is actually one component, or a single "die," on a larger, multifunction chip. Typically, FM capability is packaged on a chip or module that also provides Wi-Fi and Bluetooth capability, and is therefore often referred to as the "connectivity chip."

"Teardown analysis" looks at a device's hardware to identify functionality, estimate cost of materials, and evaluate other elements of the device's design. Figures 3 and 4 show the results of such teardowns in photos of one side of the circuit board of two smartphones with various components identified. Each of these phones use different connectivity chips, both of which include Wi-Fi, Bluetooth and FM reception capabilities.

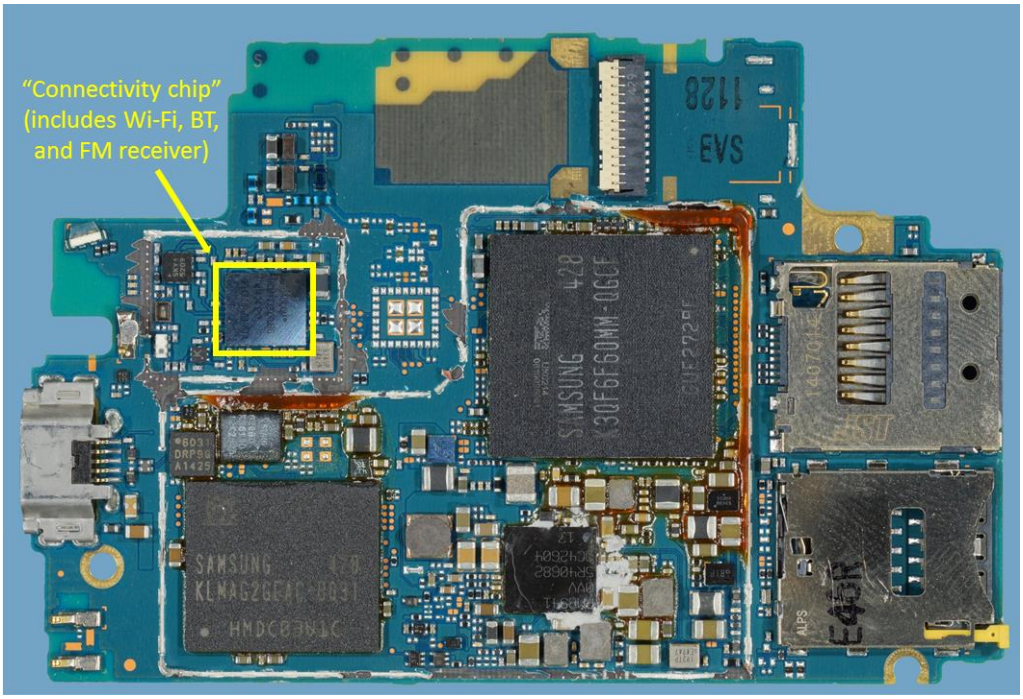

FIGURE 3 – SONY *XPERIA Z3* CIRCUIT BOARD, SHOWING BROADCOM BCM 4339 "CONNECTIVITY CHIP" (COURTESY ABI RESEARCH)

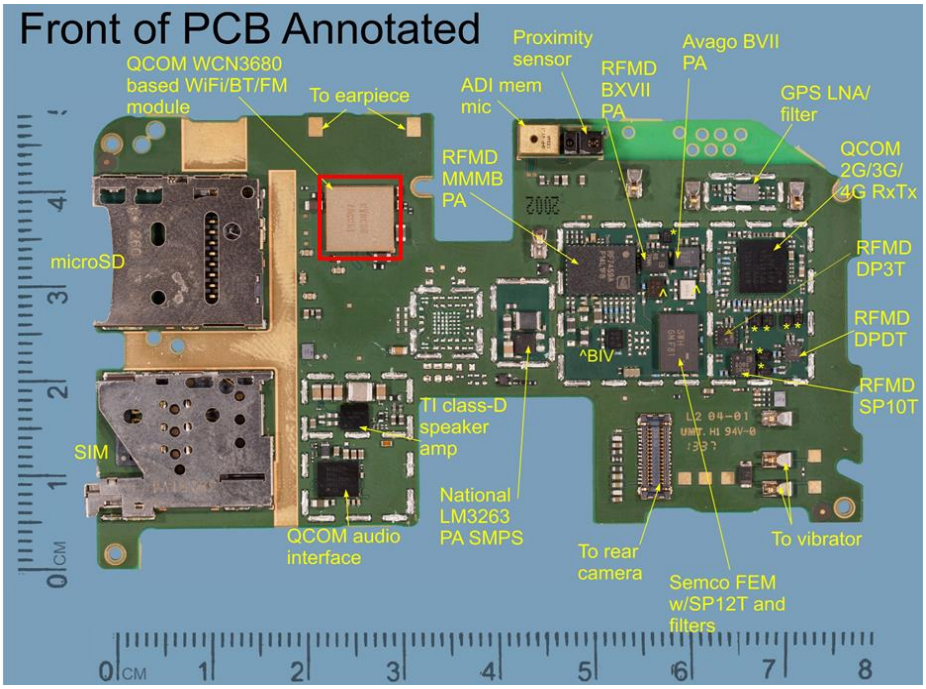

FIGURE 4 – NOKIA *1520* CIRCUIT BOARD, SHOWING QUALCOMM WCN 3680 "CONNECTIVITY CHIP" (IN RED BOX), WITH OTHER COMPONENTS IDENTIFIED AND RULERS SHOWING SCALE (COURTESY ABI RESEARCH)

Figure 5 shows an X-ray of a portion of a smartphone, again identifying various components. Even with such detailed analysis, however, in most cases it is virtually impossible to determine whether FM capability is enabled on a particular device purely by visual examination. Note the headphone jack in this photo, and in particular its numerous terminations and the many circuit board traces that lead to it.

The FM radio antenna connection can typically be among these, but an increasing variety of other devices—besides the headphone/microphone—also vie for use of this connector (e.g., credit card readers). Such competition for the limited real-estate and resources of a smartphone weighs into the decision for whether to include any particular feature—such as FM radio—on a given device.

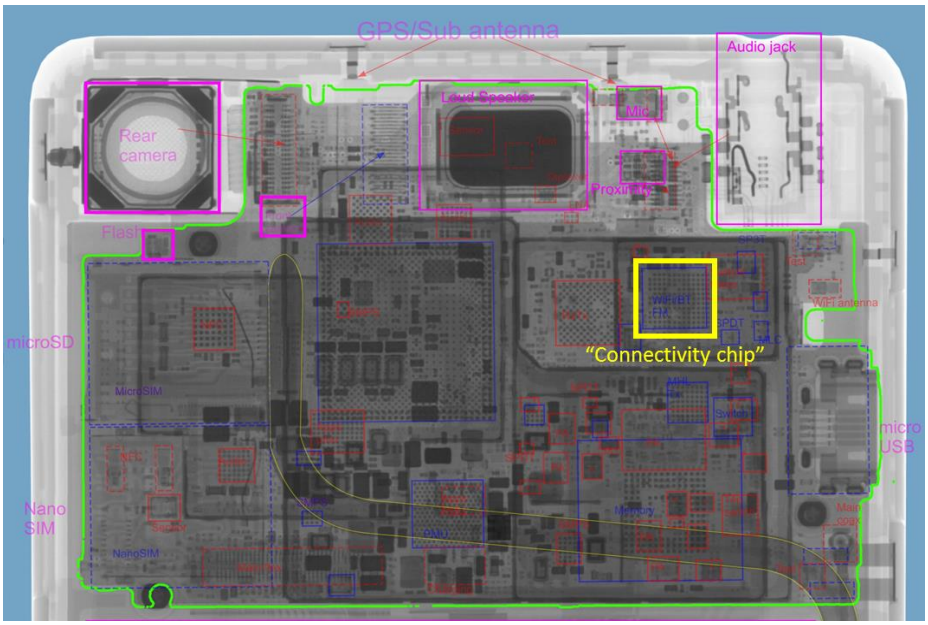

FIGURE 5 – X-RAY PHOTO DETAIL OF SONY *XPERIA Z3*, SHOWING "CONNECTIVITY CHIP" AND AUDIO JACK (COURTESY ABI RESEARCH)

Another factor in such decisions bears upon the fact that some manufacturers consider standard FM radio to be a "low-value" feature, and therefore may include it on their lower end devices but not their premium offerings. For example, Motorola includes FM reception worldwide on its *Moto G* and *Moto E* models, but not on its high-end *Moto X* product. Adding hybrid FM functionality to smartphones can help change this perception, and provide a richer, higher value experience.

II. Apple: A Special Case

Apple's *iPhone* represents a special case. Whereas a number of phones do not have their FM radio functionality enabled or exposed as a choice of the wireless carrier, the iPhone does not have this capability globally, per a decision made by the manufacturer. As Figure 1 above shows, this single decision accounts for why a very large percentage of smartphones sold in the U.S. are not FM-enabled.

NAB Labs' teardown analysis shows that all iPhones (since the 3GS model, which was released in 2009) utilize a connectivity chip that includes FM receiver capability, but in no case is FM capability enabled in the hardware.

It should be noted that Apple has enabled FM on other products, so its omission on the iPhone cannot be ascribed to the company's lacking the technology. In fact, the implementation of FM radio capability on the *iPod Nano* product line—where it has been available since its 5th generation (2009)—is widely considered to be one of the best ever produced in a handheld device. It even includes the unique, DVR-like feature of a pause/rewind buffer, allowing the user to stop and restart live radio, or to rewind up to 30 minutes back into the audio that has been received on the device.

This implies that even carriers wishing to enable FM radio capability universally (e.g., Sprint) cannot do so on any model of the *iPhone* released to date.

III. Battery Life

As mentioned above, FM radio listening generally requires significantly less current from handheld devices' power sources than does streaming audio. Because smartphones are usually operated on battery power, and users may listen to radio services for extended periods, this issue may result in substantial battery life differences between FM and streaming radio usage.

Table 2 shows a comparison of average power consumption used by FM radio in a typical FM-enabled smartphone[2] versus three popular streaming radio services on the same phone. This analysis indicates an approximate 6:1 increase in battery life using FM radio rather than streaming radio. In times of crisis, not only does FM listening provide a higher likelihood of availability of emergency information, but the additional battery life may provide valuable extra listening time during these periods, when electrical power may also be temporarily unavailable for recharging smartphone batteries.

USAGE	AVG. POWER CONSUMPTION	EXPECTED BATTERY LIFE
FM Radio	0.21 Watts	36.16 hrs
***Spotify* IP Streaming**	1.32 Watts	6.04 hrs
***Pandora* IP Streaming**	1.01 Watts	7.90 hrs
***TuneIn Radio* IP Streaming**	1.27 Watts	6.26 hrs

TABLE 2 - BATTERY LIFE COMPARISON OF FM LISTENING AND STREAMING RADIO LISTENING ON THE SAME SMARTPHONE [1]

NEXT STEPS

Increased availability of FM enabled phones in the market must be a priority for radio broadcasters. Through the adoption of already available hybrid radio capabilities, broadcasters can provide FM radio with a user experience similar to that of streaming radio on mobile devices, but without the latency, service interruptions, data consumption, battery drain and lack of local or emergency information generally associated with streaming services.

REFERENCES

[1] Sprint/NextRadio study, July 2013.

[2] Verizon Data Calculator, http://www.verizonwireless.com/b2c/splash/dataShareCalculator.jsp.

[3] NAB Labs teardown data and subsequent analysis, 2012-2015.

ACKNOWLEDGEMENTS

The authors wish to thank Jim Mielke of ABI Research, Paul Brenner of Emmis Communications, and Nick Piggott of Global Radio and the RadioDNS Project for their invaluable assistance in compiling this report.

AUTHOR INFORMATION

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[2] HTC *One M8* phone in 3G mode running native FM app.