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Riding the Solar Wind: AM Radio, the Skywave Effect, and the Mainstreaming of Rock & Roll

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Abstract

The birth of rock & roll is a topic with a rich history of scholarship rooted primarily in the liberal arts. However, one relatively unexplored aspect is the impact of long-distance radio transmission on its movement into the mainstream of popular culture. A geoscientific perspective reveals how this phenomenon, known as the skywave effect, is associated with AM as opposed to FM transmission, favoring nocturnal broadcasts in particular. This technical point of view informs existing discourses regarding cultural appropriation and the rise of the independent record labels. We invite a reading of the serendipitous broadcast of songs, voices, and recordings arising from marginalized communities as a gesture of liberation. The skywave effect reveals disruption of ideological and economical status quo as well as the propagation of late 1940s rhythm and blues music spreading over the following decades into new forms including Caribbean ska and early rock & roll.

Keywords: skywave effect, rock & roll, radio history, AM radio, music business, race records, ionosphere, twentieth century popular culture

Introduction

There is no shortage of critical accounts of the birth and early years of rock & roll. As a result, the particular issue of how this music genre moved from the margins to the center of popular culture has been addressed from multiple viewpoints. Generally speaking, these tend to fall into two broad disciplinary groups: one that follows a social-scientific orientation and another that could be described as more arts oriented comprising the liberal arts with an emphasis on the social sciences, arts as well as studies rooted in philosophy, and religion.[1] The current study aims to complement the

existing corpus by virtue of arguments based in the natural and earth sciences. We will consider concepts from atmospheric science and, to a lesser degree, astronomy, physics, and chemistry not for their own sake but in order to provide a new perspective and therefore greater appreciation for the development of rock & roll in the 1940s and 1950s.

As we would expect from the preceding look at how authors have approached this issue, the story of rock & roll's blossoming has many chapters, metaphorically speaking. Reading across disciplines provides the opportunity to recognize the contingent nature of events leading to—or at least supporting the success of a given artist, song, festival, or recording, etc. For example, the success of the Beatles is a monolithic achievement in the story of rock & roll evinced by the fact that artists, executives, and music writers continue to use it as a measuring stick to estimate the success of contemporary acts now over half a century later. While such comparisons make for eye-catching blurbs, they beg the question of false equivalency by overlooking vast differences in the cultural context of the 1960s as compared to the 2020s. Perhaps the most glaring example of this is the Beatles' iconic February 1964 Ed Sullivan premier on U.S. television. It is difficult to understand how powerful the Sullivan performance was as a gateway to U.S. consumer awareness without the pertinent fact that the entire U.S. television marketplace (over 90 percent of households in 1964) was split between only three networks. This stands in stark contrast to our current television environment in which streaming and cable outlets account for thousands of channel options while shedding a great deal of light on the question of the group's instant visibility.

This coincidence of circumstance (the fact of the Beatles' initial entry into the U.S. along with the fact of television's relative lack of programming choices at the time) are two mutually supportive factors, two elements among others in the "perfect storm" that coalesced into the phenomenon we have come to know as Beatlemania. This is one example of how historical understanding acquires greater depth by interdisciplinary perspective. In this example, the history of popular music benefits from the contribution of broadcast data typically archived under the separate discipline of mass communication. The purpose of this example is to show, by analogy, the stakes of the work at hand. Rather than looking at the rise of the Beatles in the 1960s, we will instead consider the movement of rock & roll into mainstream awareness in the 1950s. The intent of this paper is to enrich our understanding of this issue by gazing through the lens of how

radio technology interacts with geophysical phenomenon to create the possibility for very long-range broadcasts. Because of the content of these early rock & roll broadcasts, the unexpected fact of their long-distance propagation acted to disrupt social norms including segregationist efforts intended to prohibit intermingling of black and white cultures.

Questions intended to guide the current study include: what particular circumstances came together on the side of broadcast *technology* during the mid-century period? What particular circumstances came together on the side of broadcast *management* during the mid-century period? And, how did the confrontation of socio-political and scientific forces result in unanticipated benefits for the mainstreaming of a marginalized musical genre? Responding to these questions will involve research into the nature and transition from AM to FM broadcasting as well as the confrontation of scientific phenomena like the "skywave effect" that made AM broadcast behave erratically. We will consider the federal regulations this phenomenon incurred and reflect on the role of radio relative to new genres and marginalized communities. In order to prepare a context for understanding the interrelation of these issues, let us consider a selection of literature addressing how the mid-century U.S. music industry was impacted by the dynamic issues of race and the division between mainstream and marginal music forms. Additionally, scientific considerations regarding radio technology and the commercial debut of FM radio in the 1940s will prove beneficial. Following an introduction to these broader issues, we will look at the intersection of early radio technology and geophysical properties that resulted in what has been dubbed the skywave effect before a concluding discussion relating the two narratives.

Mainstreaming Race Music, Circa 1950

As Wayne Cottrell shows, the contours of the popular music mainstream in the decades leading up to the 1950s were largely determined by crooners, female vocalists, jazz and swing bands, and celebrity personalities.[2] A sample of top artists from 1930 to 1949 yields names like Louis Armstrong, Count Basie, Cab Calloway, Nat King Cole, Bing Crosby, Eddie Duchin, Duke Ellington, Benny Goodman, Bob Haggart, Billie Holiday, the Ink Spots, Sammy Kaye, Jimmie Lunceford, Vera Lynn, Glenn Miller, the Mills Brothers, Vaughn Monroe, Dinah Shore, Frank Sinatra, and Bob Wills. Although ensembles of this period tend to adhere to a rather clear divide between all-white or all-black bands, the 1930s and 40s are

important harbingers of changes to come. White bandleader Benny Goodman's hiring of black guitarist Charlie Christian or Artie Shaw's brief collaboration with Billie Holiday were notable breakdowns of the racial divide among the musician class. On the corporate level as well, the color of money appears to have trumped that of the flesh to a certain degree. Out of the list of artists above, each one was signed to a major label or to a major-owned subsidiary despite the fact that the list is split nearly 50-50 between white artists and those of color.[3] Furthermore, there is no appreciable pattern in the list to support the idea that subsidiaries are reserved for minority artists despite the fact that several scholars have observed that pattern during the 1920s.[4]

The appearance of a movement toward equitable racial representation suggested by this sample population of leading artists from the 1930s and '40s is however not indicative of the situation as it would play out in the 1950s. Instead, as authors like Geoffrey Hull have shown, there is a widening divide between the smaller upstart labels associated with the black originators of what would become rock & roll and the white-owned majors who would ultimately integrate this new sound into the mainstream. This is particularly evident in the way that the ownership of the mainstream popular music market would shift over the course of the 1950s. According to Hull, that decade in particular shows a complete reversal of fortune with respect to how quickly independent labels engaged rock & roll and how the majors were late to respond. At the start of the 1950s, the major labels maintained control of approximately 75 percent of the mainstream popular music market.[5] As the decade progressed, the majors essentially passed on this new rambunctious sound and decided to stick to the Crosby and Sinatra styles that were in favor at the onset of the swing era. More nimble and less averse to risk, it was the independent labels that gambled and won big on what would become rock & roll as it arose out of marginalized and often poorer communities. By the end of the decade, it was the independent labels that were in control of 75 percent of the popular music marketplace leaving the majors with only 25 percent.

The strategies of how rock & roll was brought into the mainstream is a topic that has been covered by a handful of authors.[6] Their work cumulatively underlines cover songs, the creation of the youth market, and the crowning of Elvis as the "king" of rock & roll as the techniques responsible for "correcting the ship" and bringing the major labels back to a position of dominance. Despite the prominent role of economics as a

driving factor, the situation is a little more complex than just profits. Beneath these issues lurks the attendant phobia of miscegenation. Music is particularly provocative of this fear of the intermixture of different races for obvious reasons including the opportunity it provides for relaxed social codes, comingling, and ultimately the fact that dancing is easily taken as stand-in or rehearsal for sexual contact. As authors like Glenn Altschuler and Randall Stephens have shown, the pairing of political ideologies and religious rhetoric in an environment of longstanding racial intolerance created a highly charged atmosphere of fear in areas like the southeastern United States, also known as the Bible Belt.[7] White hegemony supported a consistency of message across institutions like the media, schools, and churches to peddle and reinforce the idea of the demonic black man or that of the overly promiscuous jezebel black female figure as the appropriate foils for white purity.

With this cultural context in mind, let us transition to a more technical discussion to understand how the combination of geoscience and radio technology disrupted segregationist ideologies of the period. In order to guide our inquiry, consider our first research question and the new perspective these issues create. To wit, what particular circumstances came together on the side of radio broadcast *technology* during the mid-century period? How do these developments bring about the skywave effect and how does this phenomenon impact AM broadcast models at the time of rock & roll's initial distribution?

The Skywave Effect

The skywave effect is a term used to describe the behavior of some radio waves as they encounter upper regions of the atmosphere. At the border between Earth and space, the ionosphere is where the sun's energy (solar ultraviolet (UV) radiation) initially contacts the gasses of our planet's upper atmosphere. These gasses lose electrons and become ionized at various levels depending on altitude and time of day or night. This ionization occurs between roughly thirty and six hundred miles above the Earth's surface. Based on altitude, the various wavelengths of the sun's UV radiation are effectively absorbed by different levels or strata of the ionosphere. Generally speaking, the ionization is more constant and significant at the upper levels, reducing the power of the sun's rays as they move closer to the earth where the atmosphere becomes denser and the ionization is less significant. These differences in the atmosphere result in several levels or

strata within the ionosphere.[8] As radio signals move upward toward the sky, they encounter more ionization and less atmosphere. This dynamic works to progressively bend certain kinds of radio waves until they refract back towards earth mirroring the angle at which they arrived. Tracing this trajectory results in a curved, parabolic shape and signals following that trajectory back to earth are said to exhibit the skywave effect.

Radio waves represent a range of frequencies located at the low energy (i.e., low frequency/high wavelength) end of the electromagnetic spectrum. The range of radio wavelengths go from ultra-low frequency up to wavelengths just below those of the microwave frequency range. For the sake of visualization, radio waves might go from the size of a mountain to those the length of a Coke bottle. As frequency increases and wavelength decreases radio waves are able to avoid or go between the fabric of the ionosphere and are not limited by this semi-porous barrier in any serious way. However, a complicating factor is that there is a correspondence between the various layers of the ionosphere and the radio spectrum. Because ionic density increases with altitude, only higher frequency waves with shorter wavelengths can make their way through the physical gaps found in lower strata before those gaps become too small and these high frequency waves are refracted back towards Earth. As for the lower frequencies, they tend to be absorbed more readily by the greater atmospheric density of the lower levels of the ionosphere through which they spend more time as their lower and longer parabolic trajectory shows. This atmospheric friction results in an inefficient and noisy transmission.

What science shows us then is that there is a sort of goldilocks spectrum of wavelengths perfectly suited for this long-distance transmission via ionospheric refraction known as the skywave effect. Longer wavelengths (below 3 megacycles) lose too much energy due to absorption in the lower atmosphere while very high frequencies (above 30 megacycles) have wavelengths short enough that they pass through the gaps between ions and kite off into space. What we are left with then is the "high frequency" band (roughly between 3 and 30 MHz) of radio waves that will not be unduly weakened by atmospheric friction yet will nonetheless be refracted back to earth due to the influence of the ionosphere. From a theoretical point of view at least, the skywave effect presents a workable concept for unusually long-distance radio wave transmission. In actuality however, this model is subject to potentially confounding variables.

Primary among these would be the Earth's movement relative to the sun since it changes the amount of radiation fed into the Earth's ionizing system, effectively supercharging that portion in direct sunlight. Without digressing too far into the minutia of this additional impact, suffice it to recognize the simple fact of a circadian rhythm between the diurnal (presence of solar radiation) and nocturnal (absence of solar radiation). The alternance between day and night has several important effects for the model we have proposed. As we have noted, the sun charges the ionosphere by splitting off electrons from the gas particles that make up the atmosphere. During the opposing, nighttime phase, the absence of this radiation allows some of the ions to recombine thereby reducing the size of the ionosphere significantly.[9] The rather complex range of ionospheric layers or strata we find in the daytime simplifies into a compact single layer at night. A second dynamic is imparted by the solar wind as it works to push or compress this charged and stratified ionosphere closer to the daytime surface of the earth (see Figure 1). In the conceptual model we have established to this point, the presence of the sun is assumed. This then could be called a "diurnal model" of the ionosphere.

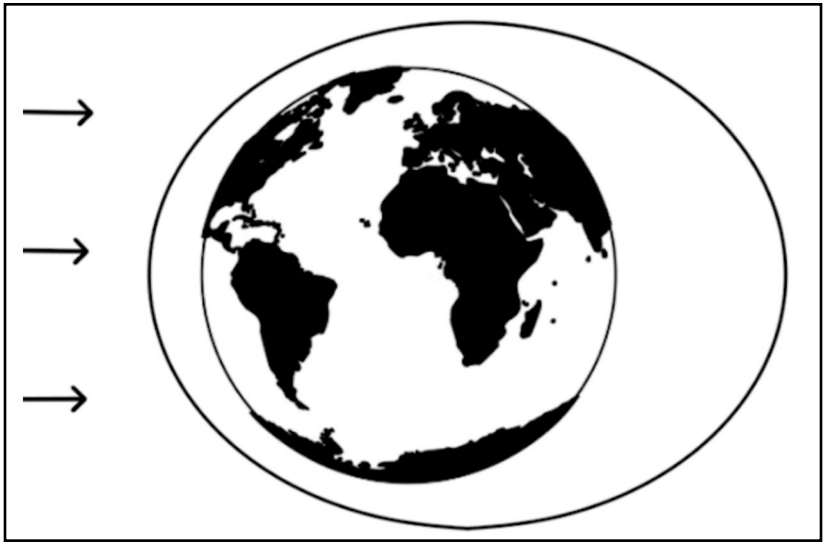

Figure 1. Solar wind (arrows) compresses the Earth's ionosphere during day, elongating it on the dark side of the planet.

At night however, we find a modified model of the ionosphere. During this period, the relative lack of solar radiation reduces the breadth of the ionosphere itself creating a more compact zone. In addition, the solar wind pulls the ionosphere away from the dark side of the Earth making it recede from the planet's surface to a higher altitude. A critical result of this decompression of the ionosphere is that it shifts the way the Earth's nighttime atmosphere interacts with radio frequencies. We will recall that the diurnal model of the ionosphere creates a dynamic in which the high frequency band of radio waves (3-30 MHz) enjoy the skywave effect—that is a long-distance or *refracted* radio wave transmission. The nocturnal model impacts our understanding of long-distance radio transmission in a couple of important ways. As noted above, the ionosphere condenses and its average altitude is increased with the help of the solar wind thus creating a higher "reflective ceiling." As the ceiling is raised in terms of altitude, the overall distance represented by the parabolic trajectory is therefore increased as well. As the solar wind elongates the "dark side" of the ionosphere, potential radio transmission distances continue to increase. Secondly, the range of usable frequencies for long-distance transmission is effectively *lowered* in favor of the longer wavelengths excluded during daytime transmission. Because the ionosphere is not ionized as strongly at night, the higher frequencies that had been refracted during the day now tend to escape into space. As a general rule of thumb, daytime transmissions present a more efficient model for high frequencies over low and the inverse applies in favor of low frequency nocturnal transmissions.[10]

AM versus FM

Following the advances of both Guglielmo Marconi and Heinrich Hertz during the closing decades of the nineteenth century, Reginald Fessenden is credited with developing continuous alternating wave transmission technology that led to the first wireless audio transmission via AM radio.[11] Although the technology for wireless audio transmission was in place by approximately 1912, the first World War delayed the technology's commercial debut. Over the first two decades of the twentieth century, various technologies emerged including microphone design and the development of vacuum tubes all supporting the debut of commercial radio in 1920 (cf. KDKA, Pittsburgh, Pennsylvania). Until the advent of FM radio and television in the 1940s, AM radio held a monopoly position over wireless audio broadcast technology. By the 1950s, the Federal Communica-

tion Commission recognized the need to regulate broadcast power. In so doing, it inadvertently led to the creation of at least one very high-power station just outside of the U.S. border that would end up broadcasting very long distances.

Given our theoretical understanding of the interaction between the Earth's ionosphere and radio signals, it is worth recognizing how this applies to the differences between AM and FM transmission. We will recall that wavelength and frequency are crucial concepts here because of the fact that smaller waves squeeze through the charged grid of the ionosphere and larger waves are progressively refracted until they return to Earth. AM transmission uses a fixed frequency as the carrier signal upon which the audio signal is inscribed as a sine wave. As a result of the sine wave's superposition onto the carrier wave, the amplitude of the carrier wave oscillates or "modulates" thus giving us the name Amplitude Modulation and the corresponding acronym, A.M. To translate this into more concrete terms, it is the AM station's carrier frequency that determines the length of a given radio wave that serves as a vehicle for its embedded audio signal. The totality of the AM band is subdivided into 116 intervals between 540 kHz and 1,700 KHz. These frequencies result in radio waves of approximately 500 to 2,000 feet in length.

When it comes to FM, it is the frequency that shifts as opposed to the amplitude of a given transmission. Instead of remaining fixed as a signal carrier, minute changes in the frequency of an FM signal trigger voltages that then operate the speaker causing audio output. Thus, when we tune into 96.2 FM, the actual operating frequencies are slightly above and slightly below 96.2 MHz. Though more complicated, the FM process creates greater fidelity and is more resilient to disturbances such as those found in the lower atmosphere and upper ionosphere, e.g., lightning. Furthermore, we will note that frequency for FM is measured in the megahertz range as opposed to the kilohertz range as found on the AM dial. If 1,000 kilohertz translates to 1 million hertz, then 1 million waves are emitted per second. On the FM dial, 100 megahertz equates to *100 million* waves per second signifying a much smaller wavelength. Indeed, that same 100 MHz frequency on the FM dial refers to a wave that is about 10 feet long as opposed to the 1,000-footlong wave transmitted by 1000 AM. Given that 1,000 kHz and 100 MHz represent the middle of the AM and FM dials respectively, the average AM signal wavelength is significantly longer than its FM counterpart.

Applying these mathematical differences to our conceptual models of the Earth's atmosphere yields some significant results. First and foremost, it is worth recalling that the differences in wavelength are such that the shorter FM radio waves tend to pass unimpeded through the ionosphere while the longer wavelengths associated with AM transmissions do not. This relatively simple observation is a necessary first step in understanding the potentially extreme geographic distances historically associated with AM radio broadcast.[12] Based on our analysis of the diurnal atmospheric model above, we will recall that lower frequencies and longer wavelength signals (AM) are restricted from long-range propagation by a couple of factors. These include the expansion and corresponding dipping of the ionosphere closer to the Earth's surface and the atmospheric interference leading to dissipation of signal strength. This results in daytime broadcast ranges in the U.S. seldom exceeding of two to three hundred miles. During overnight hours however, the situation is reversed, and the long-range transmission of AM radio waves is instead *supported* by the retraction of the ionosphere to higher altitudes. The resulting situation is an increase in broadcast ranges up to one thousand miles overnight in the U.S.[13] Figures 2 and 3 show how the skywave effect impacts diurnal broadcast ranges versus nocturnal ones.

Figure 2. The diurnal skywave effect model shows the impact of the compressed ionosphere (thick solid line) on AM (thin solid line) versus FM (dashed line) signals.

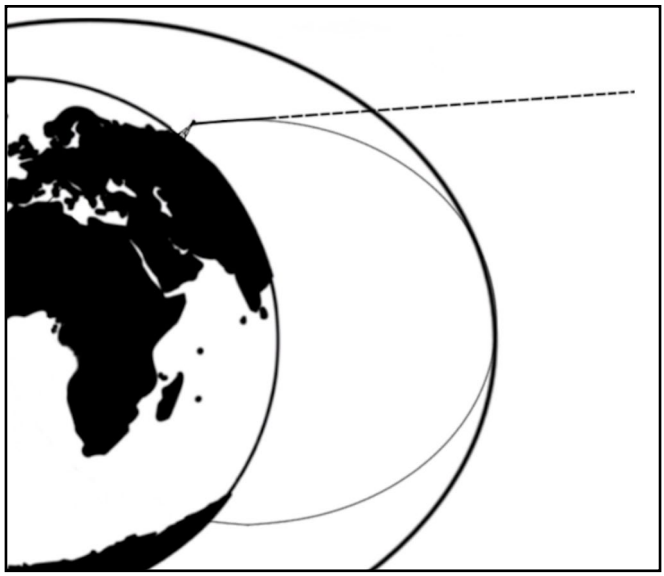

Figure 3. The nocturnal skywave effect model shows the impact of the elongated ionosphere (thick solid line) on AM (thin solid line) versus FM (dashed line) transmissions.

In terms of the commercial radio industry, the long-range propagation of AM signals has led to the need for an interesting body of federal policy to avoid chaos as competition for airwaves picks up at night. Here, the regulatory system allows us to understand how the skywave effect impacts operations on both national and international levels. Recalling that there are 116 possible AM frequencies against the fact of thousands of AM radio stations in North America, the issue of stations on the same frequency with overlapping territories arises. This has practical implications for commercial radio operators. Take for example KMVP AM 1000 in Chicago. Its powerful transmitter has a range of about 250 miles during the day but expands to 1,000 miles at night. This overlaps with two other AM stations broadcasting at 1,000 kHz: WCCD in Parma, Ohio as well as KSOO in Sioux Falls, South Dakota. Because they serve smaller markets, these latter stations are forced to reduce power or to quit broadcasting altogether during the nighttime hours. The Federal Communications Commission (FCC) is authorized to rank stations by market size from largest to smallest (*clear channel, regional, local*) and use these rankings to regulate nighttime AM station reach. In 1938 the FCC considered the U.S. Sen-

ate's Wheeler Resolution that imposed a maximum limit of 50,000 watts on radio transmitter wattage in the United States.[14] The resulting situation is that, as a *regional* station, Sioux Falls' KSOO is required to cut to half power and Parma's *local* WCCD powers down completely overnight. However, as the *clear channel* designee for its area, Chicago's KMVP AM station operates at full power. Thanks to the skywave effect, KMVP covers the entire U.S. east of the continental divide from sunset to sunrise—a nighttime coverage area of about 3.1 million square miles.

The Wheeler resolution however applies to the United States only. The reach of super high-power transmitters, also known as "flamethrowers," placed just across our border provides an extreme example of long-range AM radio wave propagation. In 1961 the RCA corporation sent technicians to Ciudad Acuña, Mexico to install a transmitter so powerful that it was outlawed in the U.S. whose border lies less than a mile to the northeast. The notorious 250,000-watt transmitter was brought online at XERF 1570 AM the following year with sufficient nocturnal reach for signal reception in Tel Aviv, Israel to the East and Melbourne, Australia to the West (see Figure 3). The voices transmitted from these flamethrowers, and how they would resonate in the areas they covered, will be the focal point of the final sections of this paper. As we transition back to the cultural context provided at the outset, let us return to our final research questions to help refocus on those issues while simultaneously holding the recent technical discussion in mind. To wit, what particular circumstances came together on the side of broadcast *management* during the mid-century period? What messages were conveyed through early rock & roll and how were they received by the various groups in the listening area?

Voices of the Night

By the year 1950, the swing and blues sounds that had animated the big bands found recourse in the trimmed down five-to-eight piece jump blues band formats as well as via the increasing number of transplant country blues musicians migrating from the south.[15] The intersection of electric amplification with the driving country blues guitar styles along with syncopated boogie-woogie piano and amplified harmonica created musical possibilities that were as infectious in their upbeat rhythms as they were original and new in their sonic energy. This is why the few copies of early rhythm and blues records that made it to western Europe were so precious to bands like the Beatles and the Rolling Stones, whose name echoes

a song title of one such Mississippi-to-Chicago transplant bluesman.[16] According to musicologists and rock critics, Ike Turner's 1951 recording of "Rocket 88" on immigrant-owned Chess Records is the first rock & roll disc.[17] This example supports the fact that during the late 1940s and early 1950s, an increasing amount of minority-owned and operated independent record labels were springing up to capture these new underground sounds. Unlike the major labels that had established protocol for promotion and broad distribution networks, these independents often operated on a comparatively modest budget with limited access to distribution. As a result, the reliance on progressively managed radio stations and younger charismatic disc jockeys to play these records was paramount.

In terms of radio station management and operations, the five-year period between 1948 and 1953 witnessed the leading edge of innovative programming models to serve marginalized communities, initially in urban settings. During this period, AM stations in Los Angeles and Cleveland brought two such charismatic DJs on board who had rapid success with shows featuring black rhythm and blues aimed at black audiences despite the fact that the DJs themselves were white. During this time frame, famed DJs Hunter Hancock in Los Angeles and Alan Freed in Cleveland started with daytime shows before migrating into evening time slots. The affiliated stations (KFVD and KGFJ 1230 AM in Los Angeles and WJW 850 AM in Cleveland) were low powered at between 1,000 and 5,000 watts which served only their respective cities during the day. In the case of Freed's WJW 850 in Cleveland however, the higher wattage and the skywave effect allowed for increased reach of up to 500 miles at night. In the right conditions, Freed's nighttime show might have reached from Cleveland south to Nashville, Tennessee, northwest to Madison, Wisconsin, and east to New York City.

While not the first station to play early rhythm and blues, Nashville's WLAC is nonetheless central to the purposes of this study. Awarded clear channel status in 1942, WLAC maxed out its wattage with a 50,000-watt signal day and night on 1510 kHz on the AM dial. By the end of the 1940s WLAC had hired a pair of DJs in their mid-twenties who were developing a nighttime show for black audiences in its region to enjoy this new genre of upbeat electric blues music. Gene Nobles and his understudy John Richbourg were later joined by Herman Grizzard and Bill "The Hossman" Allen who quickly recognized the appeal and natural fit of playing this countercultural style of music explicitly suited for late night audiences.

Through these shows, the station was branded as "the nighttime station for half the nation" as their signal reach ballooned from about three hundred miles during the day to about one thousand miles at night. WLAC's reach spanned from Nashville westward to El Paso and Denver, northward to Boston, and southward to the Caribbean.

The strongest commercial radio signal to emanate from North America however would become home to the voice of John Richbourg's understudy Robert Smith. Better known via his radio persona Wolfman Jack, Smith worked as a DJ at the infamously powerful XERF 1570 AM in Ciudad Acuña, Mexico. Wolfman Jack's rhythm and blues show ran 9 to 10 p.m. daily from 1962 to 1964. The successful operations model, learned from Richbourg in Nashville, ensured mid-century R&B and rock & roll would become one of North America's best-known exports for the better part of that decade. From another perspective, the rationale for the Federal Communications Commission's decision to limit AM transmitter strength becomes evident when one realizes that because of its power, Mexico's XERF essentially eliminated the frequency of 1570 kHz as an option for smaller stations over about a third of the planet.

The impressive impact of this highly contingent situation is illustrated by the following examples. Gregg Allman, who grew up in Jacksonville, Florida, credited WLAC with turning the Allman Brothers on to "real blues music."[18] The influence of the innovative sounds and syncopated rhythms reaching from the WLAC towers into the Caribbean also appears in musicological studies of the early development of ska music.[19] In a third example, early rock & roll guitarist Duane Eddy recalls "fond memories" of growing up in upstate New York in the late 1940s listening to nighttime broadcasts from West Virginia's WWVA and Cincinnati's WCKY.[20] In the 1950s, Eddy would do package tours with artists like Dion who likewise recalled those signals reaching him in Brooklyn, New York. By that time, Eddy recalls, both artists enjoyed the long-distance AM radio broadcasts that provided much needed company after performances as they drove into the early morning hours on the backroads of 1950s America. Taken together, these examples reveal not only the reach of the skywave effect during the final decades of AM radio's dominance, but they also underline the impact it had on both youths and musicians not only by virtue of transmitting new and interesting sounds but as a companion of sorts along their nighttime adventures.

Discussion

What can we make of these voices of the night speaking across sometimes astounding distances, traveling six hundred miles out into space only to be pulled back and received by often very different cultures? What messages are being conveyed, even if we only consider the case of early rhythm and blues music? Who is receiving these messages, and what sense is made? In the case of early rock & roll music we are considering here, we have identified some impacts on the development of musical genre by citing the Allman Brothers and the influence it had on ska. And what of the ostensibly intended audience of urban and rural blacks? This is a clear area for future research since very little exists regarding their reception of these broadcasts. As for mainstream America in the decades leading up to civil rights however, the skywave effect works to disrupt the ideological or hegemonic borders protecting the idea of white purity found in the region of the southeastern United States. From a slightly romanticized point of view, there is a certain poignancy to the idea of DJs giving voice to the oppressed, allowing their art to speak to experiences some more conservative regions deemed unfit for mainstream culture.

Looking back over the variety of perspectives engaged by this study, our scientific and industrial-operations perspectives have been brought to bear upon the socio-cultural narratives surrounding the birth of rock & roll. A new way of seeing the situation, our scientific perspective brings with it a radical objectivity as well as a unique moment to reflect. In so doing, it is hard to avoid the irony of these broadcasts juxtaposed against the historical effort to mute those same voices deemed unfit for public conversation or unworthy of basic civil rights. We might even recognize the image of transistor radio-clutching middle-class teens furtively listening to the "devil's music" under the sheets when their parents have gone to bed. Poetic justice aside, these voices of the night were nonetheless reaching vast swaths of the Earth's surface, brought along by pioneering rock & roll DJs—funky pied pipers in their own right—operating a sort of translation by their choices of what to play on the air. With the support of the skywave effect, these broadcasts were truly making legends of paupers and global musical diplomats out of common laborers.

From the perspective of the operations side of the music business, the skywave effect finds its place in the story of the major labels' loss of control of the popular music market. Prior to the equalizing impact brought about by the internet, "major" label status was not conferred simply as a

matter of larger budgets or rosters. Since the mid-twentieth century, the distinction between major and independent labels has had everything to do with the specific power to distribute and promote recordings. If a given independent label's distribution is local or regional, then major labels of the period managed larger, national and international distribution networks. It has been a long-standing strategy for successful independents to foster growth by entering into contractual distribution agreements with majors who sell access to their larger networks. By the same token, radio promotion has traditionally worked to pull recorded product through the distribution pipeline by creating visibility and generating demand. Together, radio promotion and distribution have been key components that allow major labels to introduce talent to new and distant marketplaces. The skywave effect short circuited this entire process by allowing for the independent records to momentarily achieve broad geographical distribution by way of the performance of their records on AM radio channels during nighttime broadcasts.

The science that allowed for these broadcasts to cross racial, geographical, and socio-demographic lines was not completely immune to the subtending ideological value systems. To the extent that conservative ideologies worked to force those records onto the margins and into the shadows, it also supported the growth of an unintended effect on the part of the younger generations. Perhaps it is not too much of a stretch to recognize the spirit of youthful rebellion so often associated with the rock & roll movement of the 1950s and '60s in relation to curiosity about what the apparent threat might actually be? In this respect, the portable transistor radio is an important technological innovation not simply for listening to music but as a way for listeners to seek answers and assess the gravity of the threat for themselves.

As a relatively inexpensive item of personal property, portable radios further expanded the distribution, reach, and accessibility of what some more conservative segments likely considered as a taboo or outlandish communication. Instead of the 1930s and '40s image of families gathering around the large wooden console and listening intently to the one living room radio, the transistor radio fostered a more individualized relationship with broadcast. Whether by car or by handheld transistor device, portable radios allowed for youth identity to be constructed progressively outside of the home and on the terms set by youngsters themselves. It allowed for its owners to reimagine common sites like campsites, beach parties,

sleepovers, and parking lots as impromptu music venues. Indeed, scenes from movies like *American Graffiti* repeatedly show this iconic convergence of teens parking at a malt shop and socializing around the car radio as emblematic of nightlife of the era. Paired with the skywave effect, the transistor radio allowed for these voices from the shadows to pass momentarily unbound by the various regulatory, industrial, and ideological filters—including those imposed by the major labels themselves—that would have otherwise preempted their transmission in favor of different voices.

By the end of the 1950s, the majors had lost 50 percent of their market share due to multiple factors including their assessment of rock & roll as a passing fad.[21] By using their own (mostly white) artists to re-record R&B records from the late 40s and early 50s, the majors used those covers to encourage the developing teen pop market as mainstream event. They then took necessary steps towards rebranding black rhythm & blues and turning it into something they could control, exploit, and rebrand as rock & roll. Without the physics of the skywave and the voices it carries, it is uncertain how long it would have taken these new sounds to permeate the ideological boundaries sheltering middle class youth from what was seen as a potentially corruptive cultural influence. The highly contingent, even coincidental nature of this brief window in time is underlined by the fact that by the mid 1970s, the reign of AM radio was ending and the migration of mainstream popular music to the FM dial was nearly complete. In other words, the skywave effect could have only impacted the transmission, reception, and evolution American popular music during the very years of the rebranding in question.

The birth of rock & roll is a topic with a rich history of interdisciplinary scholarship. We have imported a technical point of view to critique existing discourses regarding cultural appropriation and the rise of the independent record labels. In this context, the skywave effect invites a reading of the serendipitous broadcast of songs, voices, and recordings arising from marginalized communities as a gesture of liberation. Likewise, it reveals disruption of ideological and economical status quo as well as a new understanding of the propagation of late 1940s rhythm and blues music spreading over the following decades into new forms including Caribbean ska and early rock & roll.

Endnotes

1. A selection of recent book-length studies located under this broad disciplinary umbrella include Glenn Altschuler's *All shook up: How Rock 'n' Roll Changed America* (Oxford: Oxford University Press, 2003), Larry Birnbaum, *Before Elvis: The Prehistory of Rock 'n' Roll* (New York: Scarecrow Press, 2012), Michael Campbell, *Popular Music in America: And The Beat Goes On*, 4th ed. (Boston: Cengage Learning, 2011), Nelson George, *The Death of Rhythm and Blues* (New York: Penguin, 2003), Robert G. Pielke, *You Say You Want a Revolution: Rock Music in American Culture* (Chicago: Nelson-Hall, 1986).
   An older group of texts focuses on identity politics: Margot Jefferson, "Ripping off black music," *Harper's* (January 1973): 40-45; Eileen Southern, *The Music of Black Americans: A History* (New York: Norton, 1971); Nick Tosches, *Unsung Heroes of Rock 'n' Roll* (London: Secker & Warburg, 1984); Reebee Garofalo, "Black popular music: Crossing over or going under?" in *Rock and Popular Music: Politics, Policies, Institutions* edited by Tony Bennett et al. (New York: Routledge, 1993); Steve Perry, "Ain't No Mountain High Enough: The Politics of Crossover," in *Facing the Music: Essays on Pop Rock and culture*, edited by Simon Frith, 55-87 (New York: Pantheon, 1988) and others speaking from a more business-oriented perspective: *Rock & Roll invaders: The AM Radio DJs* (DVD), produced by Paul Eichgrun and Ross Porter (Carson City: Filmwest Associates, 1998) and Geoffrey P. Hull, *The Recording Industry* (New York: Routledge, 2004).
   More markedly interdisciplinary works include those based in religion: Mark Joseph, *Rock Gets Religion: The Battle for the Soul of the Devil's Music* (New York: WND Books, 2018); Shawn Young, *Gray Sabbath: Jesus People USA, the Evangelical Left, and the Evolution of Christian Rock* (New York: Columbia University Press, 2015), or philosophy (James Harris, *Philosophy at 33 1/3 rpm: Themes of Classic Rock Music* (Chicago: Open Court Publishing, 1993).
2. Wayne D. Cottrell, *Top Popular Music of the Early 20th Century: 1900-1949 -- Rankings, Artists & Links* (Crestline, California: Wayne D. Cottrell, 2019).

3. In 1940 the U.S. major labels included: Columbia (Louis Armstrong, Eddie Duchin, Benny Goodman, Jimmie Lunceford), its subsidiaries Vocalion (Billie Holiday) and Okeh (Bob Wills, Cab Calloway); Decca (Count Basie, Nat Cole, Bing Crosby, Bob Haggart, The Ink Spots, Vera Lynn) and its subsidiary Brunswick (The Mills Bros.); RCA (Duke Ellington, Sammy Kaye, Frank Sinatra) and its subsidiary Bluebird (Glenn Miller, Vince Monroe, Dinah Shore).
4. A selection of recent major studies addressing race records include: Al W. Blue, *Race records and the women who made them famous, Vol. 1* (CreateSpace Independent Publishing Platform, 2012); Barry Mazor, *Ralph Peer and the Making of Popular Roots Music* (Chicago: Chicago Review Press, 2015); Brian Ward and Patrick Huber, *A&R Pioneers: Architects of American Roots Music on Record* (Nashville: Vanderbilt University Press - Country Music Foundation Press, 2018).
5. In addition to G. Hull (supra), other authors have shown how independent labels became progressively associated with original black artists while majors became more associated with white "cover" versions in the 1950s. These include Billy Vera and Art Rupe, *Rip It Up: The Specialty Records Story* (Chicago: BMG Books, 2019); Randy Fox. *Shake Your Hips: The Excello Records Story* (Chicago: BMG Books, 2018) and Nadine Cohodas, *Spinning Blues Into Gold: The Chess Brothers and the Legendary Chess Records* (Winnipeg: Iconoclassic, 2012).
6. The specific issue of how rock & roll was mainstreamed include: Ed Ward, *The History of Rock & Roll, Part 1* (New York: Flatiron Books, 2017); Rich Cohen, *The Record Men: The Chess Brothers and the Birth of Rock & Roll* (New York: W. W. Norton, 2005); Portia K. Maultsby and Mellonee V. Burnim, eds., *Issues in African American Music: Power, Gender, Race, Representation* (New York: Routledge, 2016) and Nelson George, *The Death of Rhythm and Blues* (London: Penguin, 2003).
7. Recent works from authors who have addressed the threat of black music in the Bible Belt include Glenn Altschuler, *All Shook Up: How Rock 'n' Roll Changed America* (New York: Oxford University Press, 2003); Randall J Stephens, *The Devil's Music: How Christians Inspired, Condemned, and Embraced Rock 'n' Roll*

(Cambridge: Harvard University Press, 2018), Michael Bertrand, *Race, Rock, and Elvis* (Urbana: University of Illinois Press, 2000); Paul Friedlander, *Rock and Roll: A Social History* (Boulder: Westview Press, 1996); Piero Scaruffi, *A History of Rock Music* (Lincoln: iUniverse, 2003); David P. Szatmary, *Rockin' in Time: A Social History of Rock-and-Roll* (Upper Saddle River: Prentice Hall, 2004); Samuel A. Floyd, *The Power of Black Music: Interpreting Its History from Africa to the United States* (Oxford: Oxford University Press, 1995). A selection of source texts exemplifying this topic is located in the bibliography.

8. These layers are referred to as D, E, and F running from lowest to highest, (c.f.: Karl Rawer, *Wave Propagation in the Ionosphere* (Dordrecht: Kluwer Academic Publishing, 1993), John S. Seybold, *Introduction to RF Propagation* (Hoboken: John Wiley and Sons, 2005).
9. Some scholars also theorize that the ionosphere tightens up at night to better work as a refracting shield.
10. Other variations apply like seasonal or solar activity. For example during summer nights ionosphere is stronger than winter where wavelengths are longer (20 MHz vs. 10 MHz and below).
11. For more information on Fessenden and the early innovations that standardized radio broadcast technology see Hugh G. J. Aitken, *The Continuous Wave: Technology and American Radio, 1900-1932* (Princeton: Princeton University Press, 1985); Alfred Balk, *The Rise of Radio: From Marconi Through the Golden Age* (McFarland & Company, 2005); Lewis Coe, *Wireless Radio: A History* (Jefferson, North Carolina: McFarland, 1996); Sungook Hong, *Wireless: From Marconi's Black-Box to the Audion* (Ann Arbor, Michigan: MPublishing, 2001); Dennis Karwatka, "Reginald Fessenden and Radio Transmission" in *Tech Directions* 63, no. 8 (March 2004): 12.
12. For additional detail on XERF's nighttime broadcast reach, see Gene Fowler and Bill Crawford, *Border Radio* (Austin: Texas Monthly Press, 1987) and Wolfman Jack and Byron Laursen, *Have Mercy! Confessions of the Original Rock 'n' Roll Animal* (Chicago: Warner Books, 1995).
13. As for FM, the day versus night issue is moot because its high frequency signals are immune to ionospheric interference.

14. Named in honor of Burton K. Wheeler, the senator from Montana who proposed the resolution, U.S. Senate Resolution 234 passed in 1938 limiting U.S. domestic radio station output power. It has been known as the Wheeler Resolution after it was adopted by the FCC the following year.
15. In 1942, Aaron "T-Bone" Walker recorded "I Got A Break Baby" for the Capitol label. Portending the coalescence of contingent forces, it is the first record featuring what would become known as a modern rock & roll ensemble of drums, bass, keyboard and a lead singer who doubles as lead guitar/featured soloist.
16. McKinley Morganfield (1915-1981), a.k.a. Muddy Waters composed "Rolling Stone."
17. For discussion on Ike Turner's "Rocket 88" as first rock & roll record, see: Larry Birnbaum, *Before Elvis: The Prehistory of Rock 'n' Roll* (Lanham, MD: Scarecrow Press 2003), 17; John Collis, *Ike Turner – King of Rhythm* (London: The Do Not Press, 2003), 75; Jim Dawson and Steve Propes, *What Was the First Rock 'n' Roll Record?* (London: Faber & Faber, 1992); Peter Guralnick, *Last Train To Memphis: The Rise of Elvis Presley* (Boston: Little Brown 1994), 38; Robert Palmer, *Deep Blues* (London: Penguin Books, 1982).
18. For the full Gregg Allman quote, see his interview with Dennis Elsas, "Gregg Allman Shares a Fillmore East Secret" 2011 Interview with Gregg Allman, https://bestclassicbands.com/gregg-allman-interview-dennis-elsas-3-2-16/, retrieved Jan 7, 2020.
19. Paul Kauppila, "From Memphis to Kingston: An investigation into the origin of Jamaican Ska." *Social and Economic Studies* 55, no. 1/2 (Mar/Jun 2006): 78.
20. Duane Eddy, interview by Paul Linden, Nashville, Tennessee, October 4, 2021.
21. Hull, *The Recording Industry*, 58.

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Paul Linden has toured North America and Western Europe playing folk, blues, and roots as a blues and roots-americana artist. He has performed on Austin City Limits, CBS, NPR, and Mike King's award-winning documentary on Chicago Blues. Festivals and venues Linden has played include the Montreal Jazz Festival, Memphis in May blues festival, Atlanta's Fox Theater, New York's Beacon Theater, Portland's Roseland Theater, and the Filmore West. Active in blues and other American roots music, he has worked with Bo Diddley, B.B. King, Jerry McCain, Nick Moss, Susan Tedeschi, and Kim Wilson. His research interests include interdisciplinary and theoretical approaches to music industry studies. A selection of publications includes "Entrepreneurship: Theory and application in a university arts management setting," "Translating race and genre in popular music" and "Malcolm Chisholm: An Evaluation of Traditional Audio Engineering." Dr. Linden's research has been cited in the recent authoritative history of Fender amplifiers, *The Soul of Tone: 60 Years of Fender Amps* (Hal Leonard, 2007) and *Vintage Guitar Magazine*. He is also a regular contributor to magazines like the *Tone Quest Report* and the French-based magazine, *Blues & Co*.

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