

# The Market for Hearable Devices 2016-2020

## And then there were AirPods...

*Apple's unexpected entry into the hearables market heralds a period of major change. The result is likely to be a faster move to wireless headphones, an acceleration in the take-up of earbuds, and the prospect of an overall market revenue exceeding \$40 billion in 2020.*

**Nick Hunn**

WiFore Consulting,  
London.  
November 2016

[nick@wifore.com](mailto:nick@wifore.com)  
+44 7768 890 148

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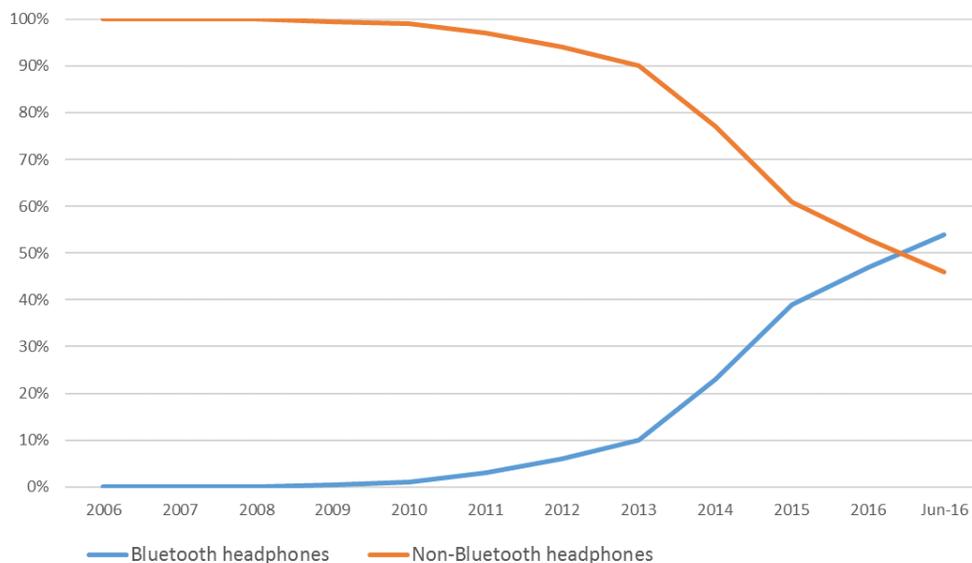
## The Market for Hearable Devices 2016 - 2020

And then there were Airpods. On September 7<sup>th</sup> 2016, Apple made three announcements that look set to alter the course of the hearables market. One had been predicted – the removal of the 3.5mm audio jack from the iPhone 7. It was a change that they described as courageous, but which many decried as retrograde. However, it fundamentally changed the dynamics of the market for wireless headphones.

The second two announcements were much bigger surprises. Apple had designed its own wireless chip, and they were entering the hearables world by launching their own brand of earbuds, known as Airpods. Both were unexpected moves. The pistol starting the hearables race had already been fired, but now it became obvious that the race was serious.

### Life before Airpods

The hearables market goes back to the first Bluetooth headsets which were launched in 2001, followed by wireless stereo headphones, which arrived a few years later. Neither made great waves in the market – headsets were associated with cabbies rather than celebrities and Bluetooth stereo headphones took almost a decade to attain any market share. In 2013, that started to change. Major brands were taken by surprise as consumers started to purchase wireless headphones. The most credible reason I've heard for the change is that it was driven by the growth of mobile video on larger handsets, with users preferring to dispense with the annoyance of cables when holding the phone screen horizontally. That's supported by research from Parks Associates [1] showing the average US smartphone user stream music or video for 90 minutes each day. Whatever the reason for the sudden popularity, there is no question that they are now fashionable.



Sources: Bluetooth SIG, NPD

Figure 1. The growth of wireless headphone sales

NPD, which tracks retail sales in the US, has reported a massive increase in sales [2], as Figure 1 illustrates. In June 2016, they reported that the overall value of wireless headphone sales in the US overtook that of wired headphones, (although the percentage of sales by units was still only 17% for wireless). With the Airpod announcement, the loss of physical audio jack on the iPhone 7 and Apple's new W1 wireless chip already being used in the latest Beats headphones, there is little doubt that the value of sales of wireless headphones will keep on rising.

The real hearables revolution began in 2014 when two European companies launched crowdfunding campaigns for earbuds. In Sweden, Earin acquired funding for a pair of Bluetooth earbuds which would stream audio. 1,500km further south, in Munich, another startup – Bragi, raised the unprecedented sum of \$3.39m for a far more ambitious hearable device – the Dash. Like Earin's product, the Dash could stream music. But it could also store and play music without the presence of a phone, as well as housing a host of biometric sensors which would feed back data to a range of fitness applications. Targeted at runners and athletes, it caught the imagination of over fifteen thousand backers and turned the ear into a subject of intense development. It was a vastly over-ambitious entry product, but Bragi have managed to get it to market and established themselves as the poster child of hearables, effectively firing the starting pistol. In their wake, many more have taken up the challenge.

At this point I should clarify what I mean by a hearable device. Previously I defined a hearable as any device which included wireless connectivity, as the differentiating factor between wired and wireless headphones. That included wireless stereo headphones and mono Bluetooth earpieces, but excluded most hearing aids which had no wireless connection to a phone. In just two years, the picture has become far more complex. When I coined the word "hearables" at the beginning of 2014 [3], the wireless headphone market was still niche, and no one had considered sound isolation, audio curation or translation as real consumer opportunities. All of those are now in development or already shipping. So now I'm considering anything that fits in or on an ear that contains a wireless link, whether that's for audio, or remote control of audio augmentation (qv).

Apple's AirPods and wireless headphones will probably drive the volume is for earbuds over the next few years, but the real innovation in hearables will come from other earbud developers, not least because of their willingness to add biometrics. The intimate, relatively isolated contact that earbuds provide, along with the stabilising effect on balance from the semi-circular canals in our ears, means that the ear is one of the best locations for sensing many physiological parameters [4]. Whilst some of the biometrics will not be applicable to headphones, some will be, and we will see them incorporated in new headphone designs.

Jabra's new CEO, Rene Tune-Svendsen described the market as "adding wearable technology to music" [5]. I like that approach, but I don't think it goes far enough. Although music is the clothes-line on which most hearables will be hung, the applications being considered are more diverse than what we've seen so far with other wearables.

A parallel area of development, which will drive innovation in both earbuds and headphones will be the rise of voice communications for Internet of Voice (IoV) applications, where talking becomes as important as listening. That will see developments in directional microphones, both in the transducers and the processing to cope with multi-microphone arrays. Bone conduction is already in use to help

with voice detection and processing and will become more common.

Allied to that is a growing set of audio processing capabilities that go beyond noise cancellation to include enhancements to curate our everyday sound and select exactly what we want to hear. I now include any of these features as the qualifying point for a hearable, although I tend to add the qualifying factor that they should be wireless with respect to their audio source or controlling device. That may be a single wireless link to a pair of headphones or tethered earbuds, or separate wireless links to left and right earbuds.

These range of options will lead to much greater differentiation in the market and blur the boundaries between basic wireless headphones, complex audio processing earbuds and hearing aids. All now fit in the spectrum of hearables and it is increasingly likely that it will be a spectrum that users move through during the course of their lives. Once a brand can win the ears of a teenager, it may own those ears for life. That is a powerful incentive to spur innovation.

### ***The wrist goes limp***

Wearable products have been pushed onto the market since the early 2000s, with limited consumer interest or sales. That changed around 2013, when large electronics manufacturers saw the start of a decline in laptops, PCs and tablets, along with commoditisation of smartphones. Many felt that wearable devices were the next big consumer “thing” [6].

As companies started to jump onto the wearables bandwagon, attention was paid to the wrist, fueled by the success of Nike and Fitbit’s activity trackers and the promotion of the smart watch as the most obvious potential growth sector. In the event, even Apple’s long-awaited watch failed to engage very large numbers of consumers, with the result that most of the hype has fallen away in this sector. The activity tracking industry has also learnt an important lesson, which is the difficulty of keeping consumers engaged. They’re not alone – turning data into a compelling and sticky experience is tricky, even when you have lots of it. When Apple released its ResearchKit [7] for medical research, medics were ecstatic about the ease with which they would be able to acquire large numbers of participants who could share their health data. A year on, they are discovering the same challenge. As one commented at a recent medical conference, “After 30 days, they might put your app away and start playing Pokemon Go, and you need to have a plan for when that happens [8].”

That issue of engagement with fitness device is taking its toll on the industry. What is a novelty one week may be consigned to the back of a drawer the following week. In order to stay in use, the user needs constant feedback which provides a compelling experience. That adds an ongoing cost to manufacturers who need to run data servers, collect data and develop data analytics. In any normal business world, that would be a service which attracts a subscription. However, in the hardware centric world of wearables, it becomes an ongoing support cost for a hardware sale. The result has been that manufacturers have either abandoned the wrist market, or watched as products have commoditised to sub \$25 prices, with support consigned to community developed free apps.

In 2014 I predicted that wearables that had to survive on the analysis of their own data would struggle, including the nascent watch market [6]. Instead, I felt that the more interesting sector would be hearables, not least because their primary appeal comes from using existing content (i.e. video and

music), rather than needing to invent a compelling feedback story for the data they generate. That means that hearables manufacturers can concentrate on hardware, leaving the customer to procure their own content in the form of music or video, from another pre-existing supplier. The growth in sales of wireless headphones seems to prove that point.

As long as audio playback is supported, hearables manufacturers can experiment with biosensors and the resulting data capture opportunities, but they can be built and tested as subsidiary services that are enhancements to the primary use case of the hearable, which is listening to audio. Without the necessity of providing compelling content themselves, hardware vendors can rely on other companies to supply the content which will keep the hearables firmly in their user's ears. It feels a much safer market proposition.

### ***Enter crowdfunding***

The evolution of the hearables market has been significantly different from the wrist market for smart watches and activity bands. The wrist was responsible for two major new startups – Fitbit and Pebble, but the majority of innovation has come from large manufacturers such as Samsung, Motorola and LG, who saw the smart watch as a natural accessory to their line of mobile phones. Because of that, they came to market early and worked their way through multiple product versions, albeit with very limited take-up. Apple trumped them at that game with a significantly better thought-through product, but not one which has yet wormed its way into most consumers' hearts.

The entry of major manufacturers brought scale and manufacturing expertise to the wearables market, resulting in some very slick products, albeit lacking any real innovation which might tempt users to purchase them. As a result, many ended up being given away with smartphones. However, the production values and supply chain management set a quality bar that made it difficult for other startups to compete. Effectively, the big boys got it wrong, but in doing so, froze out the smaller players.

The experience of the hearables market has been significantly different. Whilst the majors were attempting to woo a largely uninterested public with their wrist based products, a number of startups took advantage of the growth in crowdfunding to experiment with hearable devices. Earin and Dash started the process off, but there has been a constant stream of followers who have used crowdfunding to enter the market.

	Raised	Target	Funding	Post Campaign	Backers	Ave Price
Soundband	547,125	175,000	313%		3,982	\$ 137.40
Dash	3,390,551	260,000	1304%		15,998	\$ 211.94
Earin	972,594	179,000	543%		8,359	\$ 116.35
FreeWayz	325,208	200,000	163%		1,591	\$ 204.40
OwnPhones	767,472	250,000	307%		3,526	\$ 217.66
Snugs	6,000	75,000	8%		33	\$ 181.82
Kuai	113,276	60,000	189%		752	\$ 150.63
RealLoud	648,891	200,000	324%		1,296	\$ 500.69
Ripplebuds	750,374	50,000	1501%	469,763	5,834	\$ 209.14
Aware (united Sciences)	150,952	100,000	151%		717	\$ 210.53
Hearnotes	124,155	75,000	166%	40,095	514	\$ 319.55
Doppler Here	635,189	200,000	318%		2,855	\$ 222.48
Dot	713,451	50,000	1427%		6,570	\$ 108.59
Pugz	1,472,993	50,000	2946%	95,546	10,119	\$ 155.01
Truebuds (Pearbuds)	411,061	50,000	822%	102,973	2,987	\$ 172.09
Elbee	63,000	250,000	25%		386	\$ 163.21
Revs	2,530,756	100,000	2531%		10,569	\$ 239.45
Decibulx	263,000	50,000	526%		2,429	\$ 108.28
M4	88,159	12,000	735%		584	\$ 150.96
Phazon	1,941,933	100,000	1942%		9,569	\$ 202.94
Quieton	818,000	100,000	818%	259,565	6,729	\$ 160.14
Plugfones	427,247	40,000	1068%	54,920	4,851	\$ 99.40
Truu	172,228	50,000	1068%		1,068	\$ 161.26
LifeBeam	1,688,179	100,000	1688%		7,257	\$ 232.63
NuHeara Iqbuds	790,465	50,000	1581%		3,585	\$ 220.49
Pilot (Waverley Labs)	3,146,262	100,000	3146%	166,068	14,751	\$ 224.55
V1 AI Personal Trainer	1,688,179	100,000	1688%		7,257	\$ 232.63
Fireflies	1,115,000	20,000	5575%	141,756	11360	\$ 110.63
ProSound	307,191	30,000		11,390	1,136	\$ 270.41
Ropes USA	132,000	100,000	132%		396	\$ 333.33
AMPsound	26,031	25,000	104%		169	\$ 154.03
CLIK	127,947	90,000	142%		613	\$ 208.72
Elwin FIT	366,065	50,000	732%	27,230	2,638	\$ 149.09
ProSound H2P	237,611	30,000	792%		2,293	\$ 103.62
Axum	76,000	15,000	507%	7,887	522	\$ 160.70
Catalyst	191,213	25,000	765%		1,040	\$ 183.86
Erato	803,810	50,000	1608%		1,709	\$ 470.34
Sound by Human	467,535	150,000	312%		2,141	\$ 218.37
Sonabuds	144,564	20,000	723%		1,685	\$ 85.79
Tilde	40,663	65,000	63%		243	\$ 167.34
	<b>28,682,330</b>			<b>1,377,193</b>	<b>160,113</b>	<b>\$ 187.74</b>

**Table 1. Crowdfunding campaigns for earbuds**

Table 1 shows the major crowdfunding campaigns for earbuds and related products. We will look at how they differentiate themselves a little later. There are similar numbers of equally successful campaigns for headphones. One, by Axent, for wireless headphones with cat ears which light up, even managed to surpass the popularity of the Dash, raising \$ 3,427,341. Regardless of personal taste, the numbers show that there is certainly an appetite for these products. Around 160,000 people have put up over \$30 million for untried and untrusted devices to put in their ears. There has also been over \$2 million raised for simple hearing protection, ranging from metal earplugs to active noise cancellation and around \$14 million for wireless headphones. I'm aware of only two hearable crowdfunding campaigns which have failed to raise their target funding – those for Snugs and Elbee. That is a very low failure rate for crowdfunding, suggesting there is real interest in the hearable space.

Finding lots of backers who are excited enough to pledge money for a crowdfunding campaign is one thing. Actually getting a hearable to put in your ears is another, as Table 2 shows.

	Platform	Campaign	Promised	Delivered	Delay (months)	Comments	Main Feature
Soundband	Kickstarter	Jul-13	Dec-13	DIED		Never delivered	Surface emitters
Dash	Kickstarter	Mar-14	Dec-14	Feb-16	14		Biosensors, waterproof, music player
Earin	Kickstarter	Jun-14	Jan-15	Oct-15	9		Basic wireless earbuds
FreeWayz	Kickstarter	Jun-14	Oct-14	Late	25	Stuck on ear to ear	Built in fitness monitoring
OwnPhones	Kickstarter	Aug-14	Mar-15	DIED		Ran out of cash	Custom Fit
Snugs	Kickstarter	Sep-14	n/a			Looking for \$180k investment	Custom Fit (not Bluetooth)
Kuai	Kickstarter	Oct-14	Nov-15	Late	12		Multisport biometric headset
RealLoud	Kickstarter	Nov-14	May-15	Jun-16	13		Louder, but less damage
Ripplebuds	Kickstarter	Feb-15	Sep-16	Dec-16	3	Having issues with stereo	Noise blocking allows quieter sound
Aware (united Sciences)	Kickstarter	Apr-15	Sep-16	Late	2		Pulse Ox and EEG and custom fit
Hearnotes	Kickstarter	May-15	Sep-15	Late	14	Appears to be dead	Used Kler instead of Bluetooth
Doppler Here	Kickstarter	Jun-15	Dec-15	Mar-16	3		Audio curation
Dot	Indiegogo	Jul-15	Jun-15	Oct-16	16		Slated as just branding. Withdrawn from Kickstarter
Pugz	Indiegogo	Aug-15	Nov-15	Sep-16	10		Wired charging. Failed to get Apple MFI
Truebuds (Pearbuds)	Kickstarter	Aug-15	Mar-16	Late	8	Still waiting	
Elbee	Kickstarter	Oct-15	n/a			Failed to hit target	Uses head movement for control
Revolvs	Kickstarter	Nov-15	Jul-16	Late	4	Currently predicted Dec 16	by Onkyo + custom fitting
Decibulx	Kickstarter	Dec-15	Mar-16	Feb-16	8	Shipped early	Customer moulded
M4	Indiegogo	Jan-16	Sep-16	Late	2		Marketed as ear monitors for audiophiles
Phazon	Indiegogo	Jan-16	Oct-16	Late	1	Delayed (blaming pcbs)	Guaranteed to stay in
Quieton	Indiegogo	Mar-16	Jul-16	Late	4	Due Nov 16	Active noise cancelling - no Bluetooth
Plugfones	Kickstarter	Mar-16	Jun-16	Jul-16	1		Gym Plugfones
Truu	Kickstarter	May-16	Oct-16				Wireless charging
LifeBeam	Kickstarter	Jun-16	Dec-16				A personal trainer with AI
NuHeara Iqbuds	Indiegogo	Jun-16	Feb-17				Intellignet hearing - background reduction
Pilot (Waverley Labs)	Indiegogo	Jun-16	May-17				Translation
V1 AI Personal Trainer	Kickstarter	Jun-16	Dec-16				Tethered. Uses AI for personal training.
Fireflies	Kickstarter	Jul-16	Sep-16	Late	2	Scheduled for Nov 16	Basic wireless earbuds
ProSound	Indiegogo	Jul-16	Nov-16				Enhances hearing - cheaper than a hearing aid.
Ropes USA	Kickstarter	Jul-16	Aug-16	Aug-16		On time	Individual Sound Signature
AMPsound	Indiegogo	Aug-16	Sep-16			Due to ship	Another hearing aid earbud
CLIK	Kickstarter	Aug-16	May-17				Translates 37 languages
Elwin FIT	Kickstarter	Aug-16	Oct-16				Ex Apple engineers - infinite battery life
ProSound H2P	Indiegogo	Aug-16	Nov-16				2nd Gen - sold as hearing aid replacement
Axum	Indiegogo	Sep-16	May-17				Best sound quality for athletes
Catalyst	Kickstarter	Oct-16	Jan-17				Balanced armature, waterproof
Erato	Indiegogo	Oct-16	Dec-16				3D earbuds
Sound by Human	Indiegogo	Oct-16	Jul-17				Over ear, with translation and sleep tracking
Sonabuds	Indiegogo	Oct-16	Nov-16				Aiming to be the cheapest
Tilde	Kickstarter	Oct-16	May-17				360 deg noise cancellation

**Table 2. Success and delivery performance of crowdfunded hearable campaigns.**

This tells a rather different story, the major part of which is that designing and manufacturing hearables is a lot more difficult than most start-ups imagine. Amongst other things, it points out that there is a reason why hearing aids are expensive, which is that packing technology into such a limited space is remarkably difficult. Several of the start-ups have failed, burning through the cash without delivering a product, much to the chagrin of their funders. For those which have delivered, delays of a year or more are common. Most have needed to find substantial additional funding, highlighting the basic fact of life that crowdfunding and advanced orders do not in general support a company, particularly if it is at the bleeding edge of technology. Bragi have had to raise an additional \$22 million and have probably already burnt through most of that. Start-ups need to understand that you cannot develop hearables on the cheap.

Given the slow speed of start-ups in getting products out, it's surprising how long it has taken for major companies to bring products to market. Samsung was first, with their IconX earbuds [9] which were launched at the start of 2016, but few have been seen in the market. Sony announced their Xperia Ear [10] at the Mobile World Congress in February. It reappeared at IFA in August but has still not made it to market. Apple has unveiled their AirPods in September, promising availability in October [11], although the shipment date has slipped, with no firm date given [12], emphasising how tricky it is to mass produce a good hearable. It is a very different situation from the way that major companies

entered the smart watch space, but the more considered development and product introductions may result in more mature products which appeal to consumers.

While earbuds get the media coverage, wireless headphones are getting the sales. Apple's removal of the 3.5mm jack will put more pressure on users to go wireless. There is already a well-established group of brand name manufacturers, which provides more of a challenge for new entrants. Despite that, crowdfunding campaigns have pulled in around \$14 million from 73,000 backers and have showed that there is plenty of scope for innovation. It's interesting that the average cost of a crowdfunded earbud is \$188 and that of a wireless headphone is \$190, so consumers don't appear to be differentiating on price. These are in line with premium brands and considerably above the market average, particularly for headphones. One noticeable difference is that the average delay for shipment of a headphone is five months, against 13 for an earbud, reinforcing the point that designing and manufacturing earbuds is difficult.

### ***A multiplicity of markets***

One thing that crowdfunding has brought to the hearables market is variety in their features and applications. Despite the fanfare around the Airpod launch, Apple have been remarkably restrained in terms of functionality. Their AirPods are essentially just a wireless equivalent of their wired Earpods. They stream stereo music, as well as allowing an uplink audio channel to allow them to be used for phone calls and voice commands via Siri. There's a lot of technology in them to provide a good user experience, but virtually no feature creep beyond the spec of a good pair of headphones.

That's in stark contrast to most crowdfunded hearables, which vie to push more technology and complex applications into your ear. The prime example of over-specification was Bragi's Dash, which included a range of biometric sensors, an application processor allowing third party developers to write apps utilising the sensors, an internal music player and gesture control. By making their task so difficult, they struggled to deliver a product and probably ended up diverting too much management time into fund raising, when it would have been better used internally. They survived and shipped, but theirs should be a cautionary tale. As Table 2 shows, delays of a year or more are common.

I'm fairly sure that others in Table 2 will run out of cash before they have a product. The crowdfunded companies now face competition from industry heavyweights like Apple and Samsung. If these majors see demand, they will catch up very quickly. It's a tricky dilemma for start-ups. If the market takes off, they will be outmanoeuvred. If it fails to take off, their revenue disappears and they will fail anyway. In the next twelve months, I expect to see the more perspicacious of them working hard at wooing acquirers before their market disappears, or is taken away.

### ***Monitoring and Sports***

Bragi's target market, like many other earbud companies who incorporate biometric sensors, was the runner, who could use feedback from the sensors to help improve their training regime. It's a recurring theme for many hearable products which target a segment of the youth market for whom personal fitness and appearance is everything. The marketing and imagery used in promoting these products is redolent of Patrick Bateman and the hard bodies of American Psycho [13]. It is a group of users who tend to obsess about their appearance and who will pay for new products on a regular basis. However,

that demographic is searching for novelty as much as for fitness and requires a constant stream of new applications and services to maintain their loyalty. That is a challenge for start-ups which are primarily hardware companies. Bragi and others are relying heavily on external developers, but developing a service economy to support relatively low numbers of crowdfunded products is a business model which is probably not tenable. The only other options are to eat into your margins by developing your own apps or hoping an open source community will appear, which may well be optimistic as it's orthogonal to the user base. Because of those contradictions, the early products which have come to market are suffering as they have been unable to provide the capabilities to match their users' overinflated expectations.

Having said which, the good thing about the sports market is that it is already well established. Hearables targeting the sports market build on the fact that the ear is potentially a better site for biometrics than the wrist, along with the ability to provide instant feedback in the form of speaking your heart rate or adjusting music to help pace the tempo of an exercise regime. Today, almost all sports focused hearable products are aimed at the obsessive or professional athlete; we haven't yet seen it expand to athleisure in the same way as sports clothing, where wearing the brand is more important than sweating into it, but that may come. LifeBeam [14] is an example where they are going, claiming its AI effectively replaces your personal trainer. If it works, it could grow the market to the hopeful as well as the dedicated. However, I suspect that many choose personal trainers for other non-technical reasons, which an AI will never replace. That has not stopped hearable companies appearing to believe that "Her" is a trailer for their products, not just a film [15].

### ***Audio Curation and Augmented Hearing***

Unlike wearables for the wrist, which focused largely on phone notifications or sports and fitness, hearables are experimenting with a far more diverse set of applications, as crowdfunded start-ups have realised that there's a lot more you can do with the ear. Possibly the most unexpected crowdfunding success was Doppler's Here [16]. Doppler's original product was Dubs - a passive earplug, designed predominantly for protection for concert goers. Dubs has the great advantage over standard earplugs in that it provides fairly even attenuation across the audible frequency range so that you can enjoy the music while protecting your hearing. Although a simple product, it allowed them to get good traction with the live music industry, paving the way for their second, crowdfunded product - the Here. The Here is an active device which lets you control the sounds you hear. It can be used to reduce background noise, or you can adjust it from a phone app to enhance or curate whatever ambient sounds you are listening to. A use case it pushed was the ability to remix the sound at a concert to improve your listening experience. I'm intrigued how many users ever did that, but it obviously appealed. The fascinating point about the Here is that it does not include Bluetooth, so it can't be used to stream music. Nor does not amplify sound, so it does not fit any hearing aid category. It is purely about audio curation - a term I believe they invented. It obviously touched a chord, as the Here raised over \$600,000 from almost 3,000 backers, indicating that reducing everyday noise is a potential market. Doppler was already well funded and used their crowdfunding campaign as much for marketing and consumer testing, but it started others looking at audio curation as an application in its own right, where before this would have been seen purely as a sub-feature of a hearing aid. Doppler are now embarking on their third product, the Here One, which is adding Bluetooth music streaming. Reports of early prototypes are enthusiastic, and hint at future developments, such as real-time

translation [17].

Yes, translation. Those of us old enough to remember Douglas Adam's "Hitch-hiker's Guide to the Galaxy" will recall the Babel fish – a small, leech-like, yellow fish, which, when placed into your ear, instantly lets you understand anything said in any language [19]. According to the guide, the Babel fish "has started more and bloodier wars than anything else in the history of creation, because it has removed all barriers to communication". Not content to heed this warning, a start-up called Pilot ran a campaign for an earbud capable of real-time translation which raised over \$3 million. As with all successful crowdfunded campaigns, it fired the starting pistol for others to say they could do it better or with more features. The latest is Sound [20] – an over the ear hearable which promises translation as well as sleep monitoring. Presumably that combination is indispensable to opera lovers, who can check if they're dozing off when they realise how banal the libretto is in its original language. When these devices will get to market and how well they will work, if at all, remains to be seen. But it demonstrates how innovative the ideas are in this space.

Nuheara [21], another company working in this area, has been successful in raising investment and crowdfunding for their IQbuds – an earbud which filters out noise. It's interesting that Nuheara comes from an industrial sound protection background. They offer to amplify speech above background noise. Their take is interesting, as it's an application which has long been a major selling point for hearing aids, where hearing loss makes it more difficult to interpret speech. Nuheara are making the point that in an increasingly noisy world, even those with perfectly good hearing need help in having conversations. It's not traditional assisted hearing – it's addressing a totally new market of augmented hearing, which could become very popular.

### ***Hearing Aids – ripe for disruption?***

Ever since the first hearables came onto the scene, there has been a debate about whether this will spell the end of the hearing aid industry, as consumer products will offer the same functionality at a fraction of the price. That's very simplistic; these are very different markets with very different business models and very different customers. Hearing aids perform a considerably more complex job than just amplifying the sound. They're designed to be fitted and set up by qualified audiologists who will map the customer's hearing loss and configure a hearing aid to provide the best response. That route to market has a couple of consequences. The first is that in many cases hearing aids are sold to health providers and medical insurers who can be considered as the primary customer. The model is one which requires a product that can make money for the audiologist as well as the hearing aid manufacturer. Audiologists make their living from the service they provide. Their business model is closely tied to the capabilities of hearing aids, which let them provide high degrees of customisation and regular on-going audio tests and adjustments. Hearing Aid manufacturers reinforce this model by positioning their products as medical devices, which require FDA or equivalent certifications. That is an important strategy to maintain their distribution model, which in turn keeps the price high. The industry has also worked to promote public access with the telecoil technology, which has led to effective national regulation for access and support requirements for the hearing impaired which further protects this market model. Various groups have challenged this, most notably Apple, which has petitioned to FCC to relax its requirements for Hearing Aid Compatibility [22] in mobile phones. This would allow them to remove telecoil support from their phones, saving cost and space. They argue

that their proprietary Made for iPhone (MFI) hearing aid protocol is an acceptable alternative [23]. So far the FCC has resisted this call.

The medical market model is one reason that Personal Sound Amplification Devices (PSAPs) – devices which provide sound amplification, but without the ability to claim to be a medical grade hearing aid, have struggled in the market. A number of startups have tried to introduce these as cheaper alternatives to hearing aids over the past decade, with price points between \$200 and \$500. The issue they face is that most people with hearing loss are directed down the current audiologist route. Audiologists have little interest in providing a cheaper device which will reduce their revenue, and insurers and health services which subsidise or pay for hearing aids are reluctant to consider a product which is not medically certified and which does not have a body of audiological evidence to back it. As a result, most PSAPs have been limited to selling off the internet or the pages of magazines aimed at a 60+ readership.

The hearing aid industry is very well aware of the potential threat of PSAPs and other hearable devices. There is a reason that hearing aids are more expensive, which is that they contain an impressive amount of technology. Most consumer hearables are castigated for their short battery life – typically no more than three hours. In contrast, most hearing aids run for a week on smaller batteries. That performance comes from highly specialised silicon and some impressive low power Digital Signal Processing (DSP) chips which combine inputs from multiple microphones and apply audio algorithms to manipulate the output in response to the environment and the user's specific hearing loss. The major manufacturers have also been proactive in working with the Bluetooth SIG to develop the next generation of audio functionality built upon Bluetooth low energy [24]. A few have already licensed Apple's proprietary hearing aid protocol, but the forthcoming Bluetooth standard will extend the functionality and topology as well as providing interoperability. It will also bring these capabilities to the next generation of consumer hearables, although that could be a two-edged sword, making it easier for consumer products to provide assisted hearing capabilities.

Most serious hearables start-ups have been very careful not to advertise their products as hearing aids, presumably because they understand enough about the industry to know the issues that could raise. However, it has not stopped a few from taking that approach. AMPSound [25] seem to be the most blatant, claiming that you don't need a medical referral and offering to "boost your hearing by 125dB". If they really mean that, you probably won't need a hearing aid – you'll be deaf.

Whether or not the industry is disrupted, there is no doubt that there is a massive untapped market for hearing aids. Humanity's relatively recent addiction to music and particularly to loud music is leading to a major future problem. Hearing loss is set to be the new diabetes [26]. In a recent report the World Health Organisation (WHO) estimated that around 1.1 billion young people under the age of 30 are at serious risk of hearing loss because of their levels of sound exposure [27]. Although not as medically debilitating as other chronic long term conditions, the prospect of billions of people having hearing difficulties when they still have thirty years of working life before them will have profound effects both in the workplace and society in general.

Hearables are not just a potential solution, they could also be a culprit. One audiologist - William H. Shapiro, has estimated that 1 in 5 teenagers already have hearing loss [28], caused mainly by the use

of earbuds. He recommends they should be used for not more than 60 minute each day at 60% volume.

A UK company – Hearangel [29] has independently gone down the same route of looking at how best to control exposure, with a phone app which measures a Daily Sound Allowance, based on how you listen. It’s initially available as a smartphone app, but looks as if it has potential to be licensed in to other hearable products.

Shapiro is one of a growing number of people recommending noise cancelling headphones. The argument is that as they reduce outside noise, the listener is more likely to turn the volume down. That’s a marketing line that several hearable manufacturers are now using to promote their products.

I expect to see more media debate over the safety of hearables as ownership and listening time increases. It’s regrettable that some manufacturers pay lip service to hearing safety. I was saddened that Bragi recently announced that it was enabling higher audio output in the Dash, allowing users to increase it above the maximum safe limit. They announced that “As per European standards, the maximum recommended sound level for in-ear headphones is 85 dbA. Based on numerous customer requests, the Bragi OS 2.0 software will now allow you to go beyond this recommended limit based on your decision in each single case. The Dash will warn you when the recommended safety level is reached. Please note that Bragi does not recommend to go beyond the recommended level, as this may lead to temporary or permanent impairment or loss of hearing.” Given the headline was “Your Dash is now Louder, Better & Smarter than ever before”, their recommendation rings a little hollow.

There is little doubt that new earbuds and wireless headphones will appeal to this at-risk demographic. There’s also little doubt that they most will have their first experience of assisted hearing through the new augmented hearing features that these will begin to sport. As they recognise they have hearing loss, it provides opportunity for brands to continue to own them throughout their lives, providing a spectrum of devices to help as hearing loss increases. That may prove to be the real challenge that the hearing aid industry has to face in the longer term. Equally, it is an opportunity they could seize.

### ***Hearing Protection and Isolation***

One of the more interesting aspects of crowdfunding campaigns has been the number of them aimed at hearing protection. Although not as common as those for headphones and earbuds, they still account for several million dollars of funding, showing that at least a proportion of users have some degree of concern. Some of these differ very little from earbuds which include sound isolation, such as Doppler’s original Here and the Quieton [30]. But at the other extreme there are totally passive earplugs, of which Isolate [31]. It attracted over \$1 million of funding for a solid metal earplug.

The key to most of these products is the algorithms they contain which aim to reduce external noise. In many of these devices, they claim to go beyond traditional noise cancellation, but employ AI to understand the form of ambient noise and reduce it still further compared to the desired signal, which could be streamed music or voice input from directional microphone array. That’s akin to the capabilities of some hearing aids. How successful it will be is yet to be seen.

It will be interesting to see which of the various pitches supporting sound isolation gain the most credence with users. One potential negative effect is that it means that the wearer becomes isolated

from the world around them. At one level that means they may miss important auditory warning cues which could protect them, such as the sound of a car approaching. At another, they become distanced from people who may be speaking to them. That raises the issue of the social barriers that will arise if people start to wear these devices for long stretches of time. How society will react to that is something we don't yet know.

### ***Internet of Voice***

Voice has always been the poor cousin of hearable functionality, generally being the preserve of Bluetooth headsets for answering phone calls. For most users, or rather recipients of a call from someone using a headset, the best you could hope for was that the voice was recognisable. The more upmarket section of the industry has worked hard to improve voice quality, but in general the performance of the most devices has been mediocre, content with old fashioned, telephony quality. Trying to do voice recognition through a headset often felt like an exercise largely dependent on chance.

The perception of voice has changed dramatically over the past few years, although bizarrely, it's received limited recognition. The change started with Siri – Apple's voice assistant, which was copied and improved on with Google's Voice Search (now Now) and Microsoft's Cortana. Users have taken to it – last May Sundar Pichai, Google's CEO, reported that 20% of queries on its mobile app were now voice queries [32]. However, the best indication of where voice is going came with Amazon's launch of Alexa on the Echo at the end of 2014.

Alexa introduced users to the concept of talking to the Internet whenever they wanted to know something, buy something or play music. It signaled a major change by removing the need to interact with any device; you no longer needed to take a phone out of your product or press a button – you just spoke to the internet. It's difficult to underestimate the importance of this change. Whilst some may find it creepy, just asking a question is so natural that it's difficult to understand why it has taken so long to get there. The reality, of course, is that voice recognition is difficult. It's needed reliable, fast internet speeds, cloud services and AI to move from novelty to everyday reality, but we're now at that point where we can envisage a conversational internet. Both Amazon and Google regularly present slides that show this as the natural evolution of user input, as we progress from keyboards to mice to smartphones to just talking.



**Figure 2. The hand to mouth evolution of internet access**

Products like Amazon's Echo use multiple microphones in arrays, backed with complex signal processing algorithms. This ensures that it does a pretty good job of picking up your voice from anywhere within a room. That's in contrast to voice recognition services on most mobile phones, where you need to speak into the phone. Hearables fit well into this new world, as they extend the paradigm of talking to the Internet when you're out of range of your Echo or not holding your phone. As users start to wear hearables for more of the day, it makes sense if they use them to connect to products like Echo, extending the Voice over Internet functionality around the home or office. It requires good microphones, good noise cancellation, decent codec choices, but all of these exist. Amazon already allow manufacturers to integrate detection of the Alexa keyword into their products, and a hearable is an obvious choice, albeit one which may present a challenge for battery life. We're already seeing the Sony's Xperia Ear which was announced earlier this year, playing to exactly this market, as does Motorola's Hint. I suspect the concept of a single, mono earpiece, purely for voice control, may now be an outdated one. Instead, a high quality voice link for internet access will become a mandatory feature for all hearables. Manufacturers need to take note that this needs a higher quality specification than many current devices provide for voice calls. Incidentally, I suspect that the Smart Home market will struggle to go anywhere until we have a future generation of hearables to control it.

It is worth pointing out that Amazon is investing heavily in voice for Internet. They've released the Alexa Skills Kit [33], which is a collection of APIs and tools to allow developers to integrate Alexa's voice recognition into their own products or applications, powered by Amazon's Alexa Voice Services [34]. They've also set up a \$100 million Alexa Fund [35] to invest in companies that want to innovate with voice. It is a very serious commitment to accelerate the move from hand to mouth as the next stage of internet evolution. They are not the only company adding the capability for voice detection. Sensory [36] have been adding keyword recognition for devices for many years and provide another route to Alexa integration.

There are rumours that both Google and Microsoft are working on hearable devices which are expected to concentrate on voice recognition [37]. Google also has a project Aura which is allegedly based on bone conduction, with a second device aimed at the sports market [38] and there are rumours of a device called Clip from Microsoft – a voice detection device tailored for women [39]. Whether these are real or just industry speculation is difficult to tell, but with Amazon setting the bar with Alexa, it is a pretty safe assumption that both Google and Microsoft will be working on something to compete.

### ***Industrial Hearables***

Although most of the noise around hearables is in the consumer space, there is much potential in the commercial and industrial space, especially where there are health and safety considerations around ambient noise levels. Although most start-ups are concentrating on consumers, which is where they can smell early sales, there is an equally important market for industrial use. The causes of noise-induced hearing loss are changing. Previous generations who were exposed to occupational noise – typically men who are now approaching or over retirement age, suffered hearing loss from noise at work. In the last twenty years, health and safety legislation has had a huge impact, providing ear protection and significantly lowering the risk of damage.

However, it's still estimated that noise induced hearing loss is the number one occupational disease,

affecting around 250 million workers [41]. Whilst industrial hearing protection has become commonplace, it is still fairly basic, mostly in the form of earplugs or ear defenders, which, although they provide protection, may not necessarily be ideal for the job, as they inhibit communication. Some hearing aid providers play in this area and a few of the new hearables companies are beginning to address this opportunity by adding voice communications and active noise isolation to their products, specifically targeting this market. Others are going one step further by monitoring the sound density in the ear, providing a log of noise exposure in the workplace.

A Canadian company, EERS [48], is making an interesting pitch to this market. Their hearables have focused on ensuring a worker can communicate and stay protected at all times. This includes “the ability for a health and safety administrator to review reports on the status of their worker’s hearing health, so the CEO can sleep well knowing hearing loss is no longer a risk for his workers and a liability for the company.” They’ve just won first place in a competition run by the US’ National Institute for Occupational Safety and Health (NIOSH), which aims to provide solutions to reducing hearing loss from workplace exposures [40]. In the UK, another startup – Eartex [42] is taking a similar approach. Companies need that type of vision of the wider business model and Return on Investment if they are going to grow this market.

## **Audiometry**

One interesting area of development is audiometry – testing a patient’s degree of hearing loss. It’s of particular interest because it is effectively the main barrier that distinguishes medically certified Hearing Aids from any other hearable. It’s why the audiologist is such an important part of the hearing aid business model, as they are effectively acting as the gatekeeper for the hearing aid industry. Once you accept you have a hearing problem and visit an audiologist, you’re almost certainly going to go down the route that ends with the purchase of a hearing aid, just as a visit to the optician ends up with personalised glasses or contact lenses.

It means that audiometry is the important, missing part of disruption. Whilst almost everything we see in market coverage is about new hearables, which may or may not claim to challenge hearing aids or PSAPs, we see little about innovation in audiometry. As it’s not hardware, it’s not sexy. Despite that, it is an area ripe for innovation, as it’s increasingly easy to automate audiometry and dispense with the audiologist.

Jacoti is the most advanced company I’ve seen in this area. They have developed a software based solution that runs on mobile phones. Their Hearing Suite [43] is a low latency, sound processing app which runs a series of algorithms to determine what level of compensation needs to be applied to a hearing aid or hearable to correct hearing loss. Their apps have obtained FDA and CE medical approval. It is a platform which could be the Trojan horse for disruption, but rather than being seen as one of the most valuable assets in this sector, they’re surprisingly little known.

They’re not alone. An Australian start-up with background in cochlear implants and audiology is trying to “take the black magic out by letting the user retain greater control over their hearing aids”. Blamey Saunders [44] have developed an online hearing test allowing their own design of hearing aid to be adjusted prior to shipment to the customer and then fine-tuned with a phone app. They claim this significantly reduces the cost of ownership.

A similar approach is used by Even with their Earprint headphones [45], which boast sound virtualisation by using the same type of audio testing technique the first time you wear them, resulting in an “audio prescription” which sets the response of the headphones. They’re not aiming to replace an audiologist, but applying audiometric techniques to improve your listening experience.

Audiometry is not just confined to fitting hearing aids. The most bizarre audiometry application I’ve seen comes from NEC, who are proposing that you can use your ear to replace your password. Their earbuds play a sound in your ear and then analyse the resulting resonance. They believe they can uniquely identify the wearer in less than a second. They hope to have the technology on the market by late 2018 [46].

### ***Custom Fit and Appearance***

There is one noticeable difference between most hearing aids and the new earbuds we’re seeing from crowdfunded startups, which is size. Hearing aids are designed to be as small and unobtrusive as possible, largely because of a perception that there is still a stigma associated with wearing a hearing aid, which typically delays users from acquiring a hearing aid until around ten years from the point when they would have first benefitted from having one.

In contrast, most crowdfunded hearables tend to be much larger and more ostentatious. These generally make a statement about themselves and the person wearing them, as well as promoting the brand. It probably also indicates the relatively lower level of manufacturing technology expertise within these companies, which relies on conventional production techniques which are more accessible, but results in larger products.

Within both of these markets, we are seeing the rise of another differentiator – custom fit. Custom fit hearables, whether for top end hearing aids, or earpieces for successful musicians who can afford them have been around since the mid 80s from specialist companies like Future Sonics [47].

Custom fitting has always been promoted as a professional differentiator, justifying value at the top end of the market. It’s provided an opportunity for a number of companies to attempt to find ways to bring this to a self-fit, or more accessible consumer product. Eers [48] was one of the first companies to launch mid-tier custom products; Decibulz [49] have followed, along with Revolz [50], Uvero [51], Snugs [52], OwnPhones [53] and Fuze [54]. Despite the consumer interest in custom fit, what is interesting is that it’s hardly mentioned in consumer reviews (for the products which managed to ship), with most attention being paid to the old issues of battery life, audio quality and pairing. Until those are fixed, custom fitting may be a secondary differentiator. There is also the challenge of existing companies such as United Sciences [55] have a well-established business in custom fit and who already license their technology to major partners.

### ***Pseudoscience***

We saw with the AMPSound claim to “boost your hearing by 125dB”, that accuracy is not always one of the hallmarks of crowdfunded companies. The rash of campaigns, each trying to out-specify the previous one has led to a rash of pseudo-scientific claims, which range from self-powered devices which never need charging, to ones which can train the ear to listen better or even one that generates

sound in an entirely new way to help protect your hearing.

I'm not sure that there are any deliberate charlatans, but there are certainly a worrying number of people who have had an idea, but have little real knowledge of how to turn it into reality. Table 2, which shows the progress of crowdfunded companies, illustrates that \$2-3 million of supporters' money has already been lost and another \$5 – 6 million looks at risk. Whilst that is really just a reminder of caveat emptor for people funding these campaigns, there is a risk it could lead to a backlash. The same is true for the pseudo-science which promises the impossible. At some point soon, the industry needs some major players to launch technology which works and which does not hang consumers out to dry on the bleeding edge of unquestioned technical optimism.

### ***The new Audioscape***

One interesting feature of the development of the hearables market so far has been the dominance of Bluetooth as the standard behind every successful product. Hearnotes [56] pushed Klear as an alternative wireless technology, while Aivvy Q [57] went for Wi-Fi for shared audio. Despite successful funding campaigns, both appear to have sunk without trace. Bluetooth is clearly winning. That doesn't mean there is no competition. Audio is a market which Wi-Fi would like to own and its proponents will keep on trying. In some non-phone related areas, such as industrial, there are opportunities for other standards, such as FreeLinc Technologies [58] who are already supplying a second generation Near Field Magnetic Induction (NFMI) solution to commercial and military customers.

So far, almost everyone who has funded a campaign or bought a hearable device has done so to play music. Despite some negative media coverage from the audiophile end of the market, it seems that users are now content with Bluetooth's performance, although pairing is still often cited as being an annoyance. That's probably an implementation issue, as pairing for Apple's new AirPods looks very slick and doesn't appear to need anything not currently in the Bluetooth specification. As the market starts to consolidate, it should coincide with the release of a new generation of Bluetooth audio standards. The Bluetooth standards that almost all current wireless audio products are based on have been around for over a decade. They do a perfectly good job of streaming audio and supporting hands-free phone calls, but users are going to want more. The next generation of the standard, which has been driven by a combination of traditional Bluetooth companies and the hearing aid industry, will bring some important new features [24]. These include the ability to share music with friends who are wearing compatible Bluetooth hearables, either from a personal device or TV, or in public places like cinemas, schools or clubs.

The topology of audio will also change. Today's standard assumed that the most important device in the audio ecosystem was the car, as that's where users sat and talked on their phone or listened to music. The next generation of standards hands that control back to the user, making it simple to move between TV, tablet, video player and music stream, based on where you are and what you feel like doing. As we move towards a future of driverless cars, the concept of handsfree becomes an anachronism. The new future is for the far more personal world of sound and voice that constantly surrounds us.

### The Market Opportunity

And so to the numbers. The methodology I've used for this report is the same as I used for my survey of the wearables market. It largely ignores the technology and instead analyse why users would want to buy and use these devices. At the time, I was criticised for predicting low numbers for smart watches, suggesting that Apple's first year sales for their watch would only be around \$3.5 billion. Their recent announcement that they are number two in terms of watch revenue, putting them between Rolex at \$4.7 billion and Fossil at \$3.2 billion suggests that it's a valid methodology to use for emerging technology markets.

Unlike other wearables, hearables have generated a host of different categories, as we've seen above. Figure 3 breaks down the differences. It's still the case that most purchasers will initially buy them for audio playback, but as the quality of other applications improves, we may find that audio playback is taken for granted and the purchase decision starts to be based on these other functions. To that extent, Figure 3 envisages the future. For the next few years, we need to look at growth in more distinct sectors.

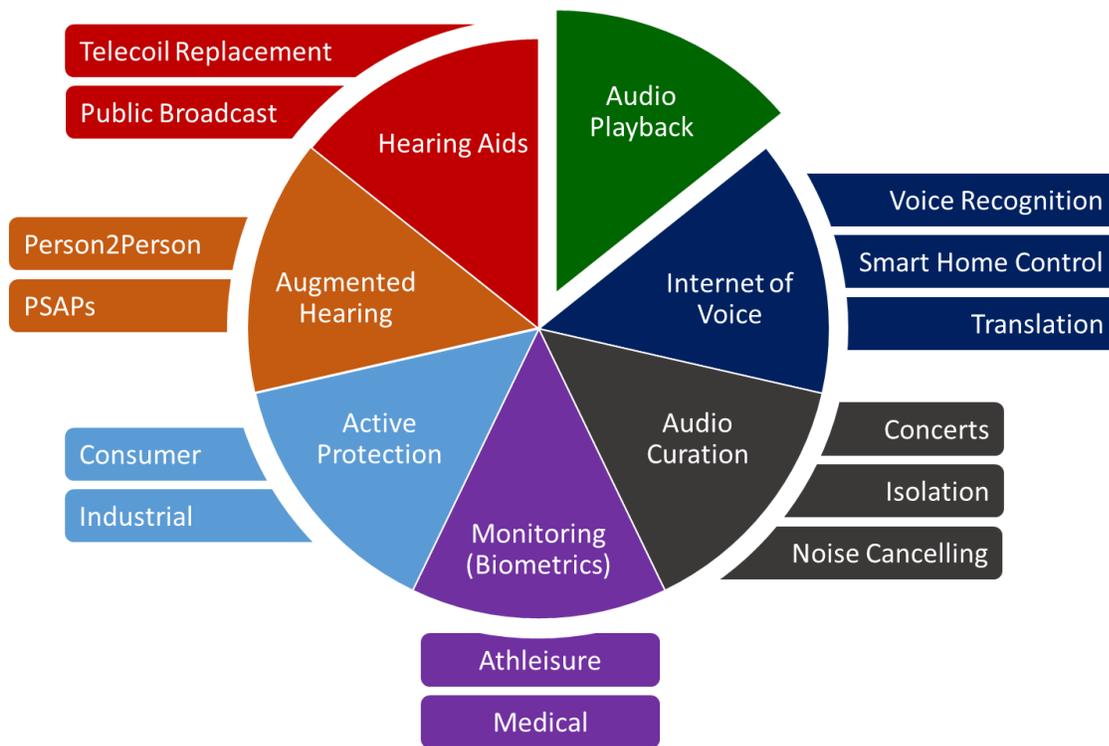


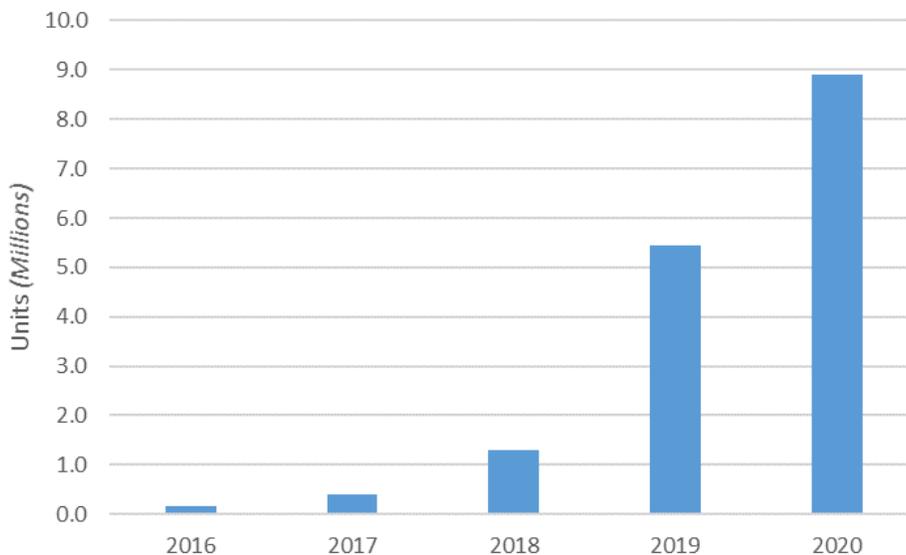
Figure 3. Market segmentation for hearables.

### **Industrial**

It easiest to start with the industrial market, as that is fairly self-contained. This market will require more robust solutions than the consumer space, but has the advantage that it relies less on fashion and can concentrate on doing a limited number of things well. ABI research has estimated that the market will reach shipments of a million units in 2021 [59]. That seems very low, not least because they imply that it includes hearables for any enterprise customer who wants to “take calls quickly and easily”. If that is the case, and they include cordless headsets, then one million feels decidedly pessimistic.

I suspect that they are missing the real reason for rapid growth, which is in-ear noise monitoring. As this becomes available, there will be a growing desire from companies to distinguish hearing loss due to employment from recreational hearing loss, as younger members of staff inflict even greater damage on their ears from their leisure activities than they do at work. There is a massive potential liability building from hearing damage, which employees may level at companies, claiming inadequate protection. Any solution which lets a company monitor the efficacy of the hearing protection they provide, as well as indicating whether it is being worn correctly, will become extremely valuable.

One employer that recognises this is the military. The US Army is already investing in hearables, having purchased 20,000 Tactical Communication and Protective System (TCAPS) for soldiers, at a cost of \$2,000 each [60]. The military alone could get close to the million units market in 2020.

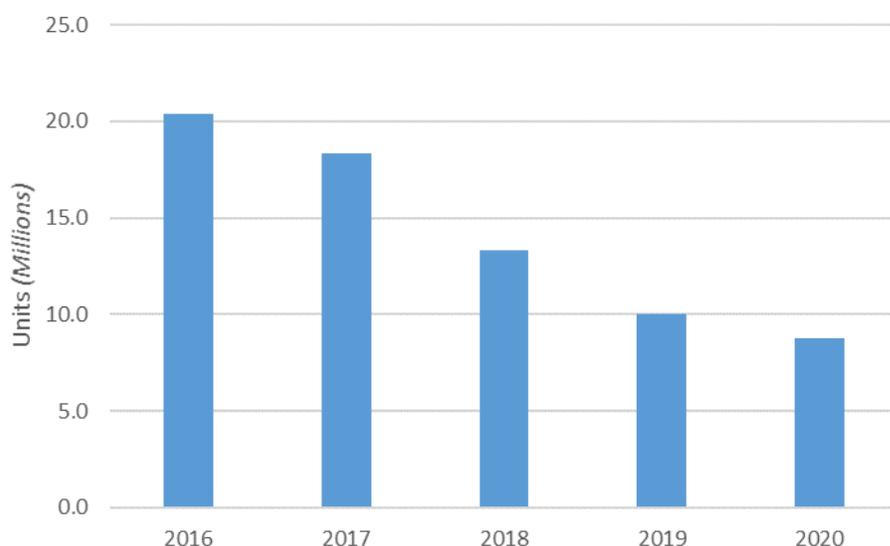


**Figure 4. Sales of Industrial Hearables.**

For that reason, I’m expecting to see rapid growth, starting to take off in 2018 as initial trial deployments start to provide results. By 2020, unit sales could grow to just under 9 million devices. These are the one hearable device for where there should also be a predictable additional service revenue, as companies pay to monitor employee exposure. The key to growth is probably going to be working with industrial insurers, who may subsidise or mandate this form of protection.

### ***Mono headsets***

The mono Bluetooth headset has been in decline for the last few years, largely because of the increasing inclusion of handsfree kits in cars. I could claim the car as a very expensive go-faster hearable, but that would be gilding the lily, so I'm just charting the headset's terminal decline over the next five years.



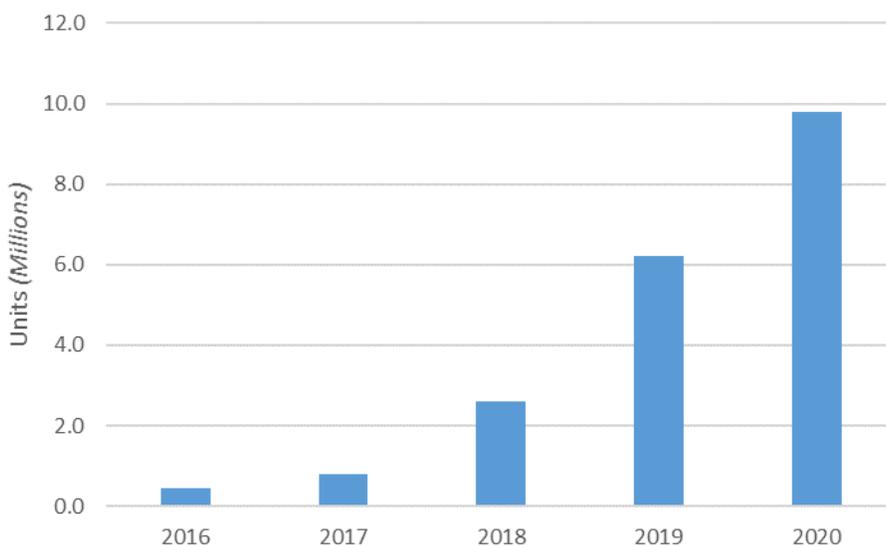
**Figure 5. Sales of mono Bluetooth headsets.**

Some would argue there is a market for mono earbuds for the Voice over Internet market, citing devices like the Xperia Ear, the Clip and Hint, but I don't see it. With these features appearing in more capable hearables it's difficult to see why anyone would buy a product that is so limited. For that reason I think the trend can only be down, for a product which is largely commoditised already. If some sell, then I think they will just be noise in the overall numbers. By 2020, the market value will struggle to exceed \$100 million.

### ***Hearing Aids and PSAPs***

The next market segment is hearing aids. Despite the doom-merchants blandishments, I don't believe that there will be any significant disruption in the next five years. Instead I suspect their market may grow.

The first reason is, as I've explained above, that they have a very well-established business model which involves audiologists, insurers and health services. Where hearing aids are provided or subsidised, that's generally a multi-decade commitment by the provider, as hearing loss doesn't go away. Market structures and commitments like that are remarkably resistant to disruption. There will be price pressure, but equally there will be a much expanded market opportunity as the stigma of hearing aids is likely to be removed by branded hearables. Today the industry reckons that only around one in ten people who could benefit from a hearing aid owns one. Add to that the new cohort of hearing damaged youngsters and it's clear that the industry is barely addressing 5% of the total addressable market.



**Figure 6. Unit Sales of Bluetooth Hearing Aids**

For this report, I am only including hearing aids and PSAPs which incorporate Bluetooth functionality. Until 2018, that will be limited to Apple’s proprietary Bluetooth low energy solution which has been licensed by some of the major manufacturers. There may also be a few hearing aids from Samsung, which has been starting to enter this market. From 2018 I expect to see the new Bluetooth standard coming to market, with a growing number of hearing aids incorporating it.

To some extent, the volumes shown in Figure 6 are just going to replace numbers of existing, non-Bluetooth hearing aids, as the Bluetooth functionality becomes a standard feature across the range, but I also expect to see overall growth as hearing aids begin to lose their stigma. These numbers still only represent that potential 5% of users who would benefit from a hearing aid, so the opportunity for increased sales is massive. I don’t expect to see any significant reduction of price in this timespan, as functionality will increase, keeping the price point stable, which means the market in 2020 is valued at almost \$13 billion.

### ***Earbuds***

That brings us to the markets for earbuds and wireless headphones. Whilst crowdfunded companies have illustrated the pent-up demand, the numbers are far more likely to come from the major incumbents in the headphone market and companies like Apple and Samsung who position earbuds as phone accessories. As consumer interest increases, it will attract other major companies which want to extend their brand equity. Fender have announced some top end monitor quality products, albeit wired, based on their acquisition of Aurisonics [61], and companies like Onkyo and other leading ODMs are already active in putting their technology behind other names. I expect we will also see own-brand devices from other phone companies alongside offerings from the traditional audio brands.

What has changed the dynamic is Apple’s decision to go wireless, as well as introducing their own AirPods. They have immense brand loyalty, which goes beyond the iPhone itself to the way of using it. If anyone is going to make earbuds desirable it’s likely to be Apple. On that basis I’ve calculated a rising

acceptance of iPhone users who will buy AirPods, rising to around 4% of users by 2020. That may seem conservative, but as we'll see in social challenges, Apple has a number of barriers to solve. I'm also assuming that whilst some of those users will change their iPhone on an annual basis, they'll keep their AirPods for an average of 30 months. That may be too long, but it seems that the refresh rate for audio accessories is still considerably longer than for phones.

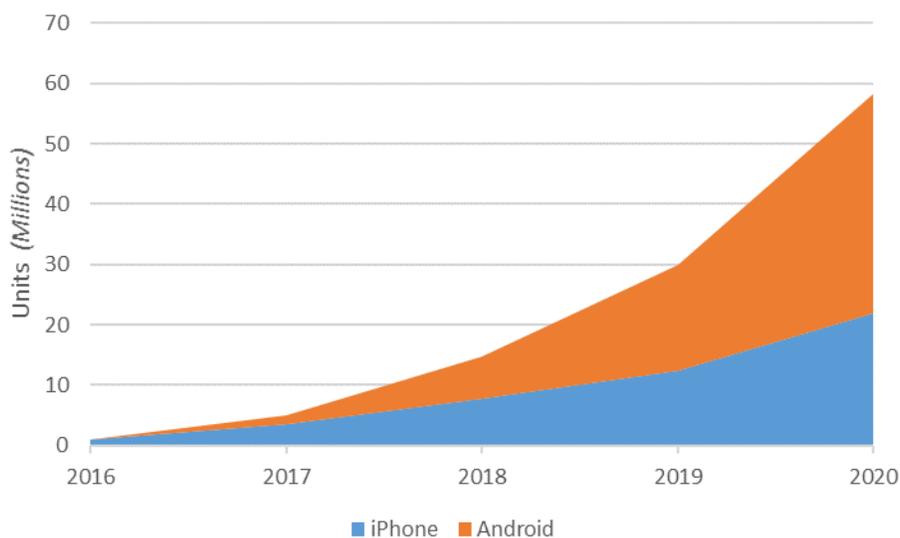
Current projections put iPhone sales for 2020 at 427 million, giving corresponding Airpod sales at 16.7 million. It's not a stellar growth, but I'm not sure Apple is expecting much more than that. AirPods are so different from any other wireless earbud that there could well be considerable social barriers to surmount, which are detailed below in the challenges the industry faces.

Apple won't be the only supplier of earbuds. As we've seen above, a lot of different market segmentation is happening as different companies develop new features. Because of this, I would expect that other vendors would capture at least a quarter of the iPhone earbud market. Most of that will probably come from the brands we already know in the headphone market, although it will be interesting to see whether Apple allows Beats to compete with the Airpod.

There is no reason why Android owners won't want to join in. I suspect that some Android handset vendors are keen to follow Apple in removing the jack in favour of wireless, but we probably won't see those models until the second half of 2017, which will delay the Android market. Samsung already has an offering in the form of its IconX earbuds, but put alongside the Airpod they already look rather tired and clumsy. AirPods are iconic; IconX are not. Some Android owners will buy AirPods, but without Siri, the value of the Airpod is fairly limited, so I suspect those sales will be small.

The other issue which Android has is that it's not particularly well architected for any complex audio applications – it often feels as if audio support has been added piecemeal as an afterthought. That's before you hit the issues resulting from the fragmentation of the Android platform. As we've seen above, for hearables to take off, manufacturers need a seamless integration of music streaming, concurrent voice support for Internet of Voice and control, plus the ability to take data from biosensors. To put that all together needs a much better controlled Android platform than we have in most phones today. Google's Pixel may be the start of the journey towards achieving that. Ben Thomson makes an important observation at this [Stratechery](#) site, that "With the Pixel Phone Google is leveraging the Android platform to build a differentiated experience that Google is uniquely capable of delivering [62]. Or as Hiroshi Lockheimer, head of Android puts it in an interview with Bloomberg [63]: "Pixel is pure Google, which is Android plus a whole lot of other stuff". I don't know what is under the hood, but this could be what Android needs in order to become the driver rather than a bit player in hearables.

That's not to say Android owners won't want earbuds – it's just that the Android market is likely to lag behind iPhone by around a year. The greater number of Android handsets will mean that volumes for Android will start to overtake those for iPhone around the start of 2019. However, for hearables companies, that's a warning that they should probably concentrate their development efforts on the iPhone market if they want to test new innovations.



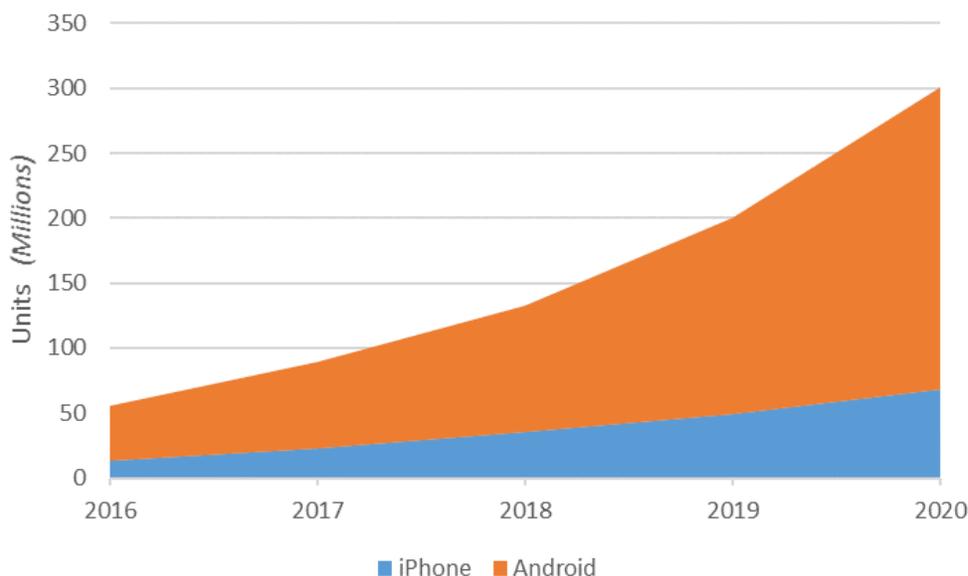
**Figure 7. Earbuds sales by phone ownership.**

That could easily change. If Google decides to launch a desirable hearable with the next generation of Pixel phone, or if Samsung launch a real Airpod contender, the market could quickly become dominated by the Android platform. We are still at the foothills of the growth curve for earbuds and much could change.

### **Wireless Headphones**

This brings us to wireless headphones, which is much more straightforward. So far, the market has been dominated by the major brands, with Beats the market leader [1], followed by LG, Bose, Jaybird and Skullcandy. It's difficult to gauge the exact number of wireless stereo headphones being sold, as there are a large number of low cost devices based on reference designs being manufactured in the Far East. Market forecasts that concentrate on branded devices suggest the total number of headphones was around 331 million units in 2015, of which 14% were wireless, giving us around 46 million devices [64]. Other analysts, such as SAR insights, who track chip shipments believe it could be significantly higher [65], although some of these are destined for applications such as handsfree kits in cars. They believe that almost double the quantity of stereo headsets may be shipping. I suspect I may be underestimating the current number of units both in stereo and mono headsets, but the ones I'm missing will be at the bottom of the price range, so won't have a large effect on overall revenues, which will be dominated by the brands.

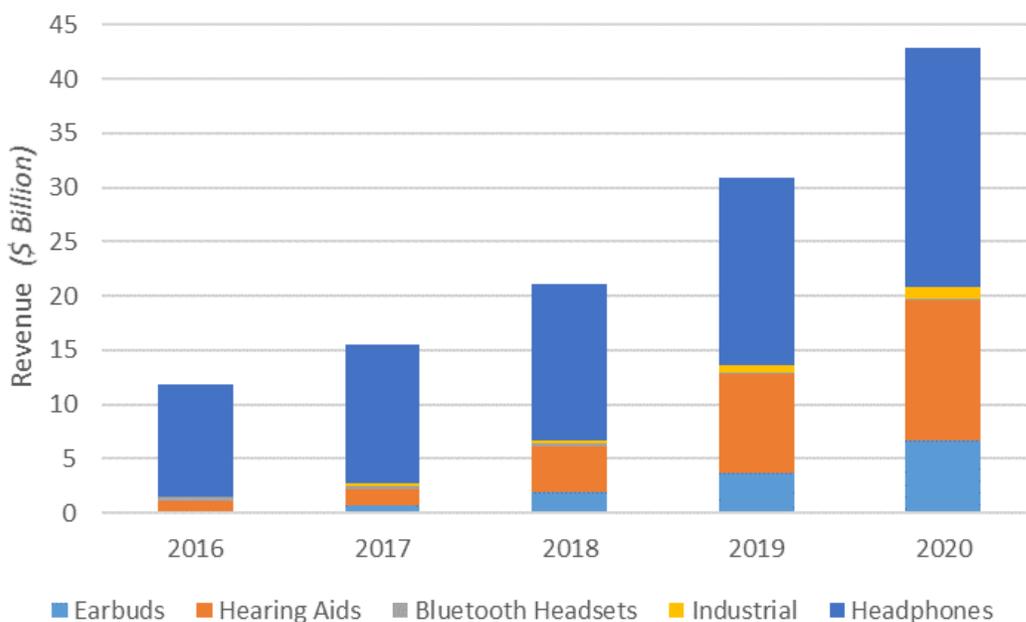
Again, the removal of the 3.5mm jack will have an enormous effect on the wireless headphone market. L&F Capital Management estimated that it could be a \$5 billion revenue opportunity in the coming year just for Beats [66]. I believe the attach rates for headphones will rise to 40% in 2020, of which 40% will be wireless, accounting for almost 70 million unit shipments to iPhone owners. Android will be slower to make the transition to wireless and overall revenue of these will be diluted by cheaper models, but will still grow to 231 million units in 2020.



**Figure 8. Wireless Stereo Headphone market by phone ownership**

There will be other market areas, particularly for low latency gaming headphones, but with the coming developments in Bluetooth, these applications are likely to be served by mainstream headphones rather than being a major category in their own right.

Putting these together gives us the overall market revenue, shown in Figure 9.



**Figure 9. Overall market revenue for hearables.**

Today, the value comes predominantly from wireless headphones. The hearing aid numbers only represent hearing aids or PSAPs with Bluetooth, which is still only a small percentage of shipments. That will change in the next few years, taking them to the second highest sector by 2020.

From the next few years earbuds can probably best be described as an experiment, but one which, if it attracts users could balloon. I remain cautious about how long that will take; they will do well to reach \$7 billion by the end of 2020. But if one manufacturer gets it right, they could eat into the headphone market. The overall revenue will probably not change as the numbers are based on the percentage of users who move to a wireless audio solution. However, earbuds may hold a higher market price for longer, advantaging manufacturers who do corner that sector.

When the new low power Bluetooth standard does arrive in products, it will signal a second wave of innovation. That will extend battery life significantly, taking away some of the pain of charging, and as reference designs start to appear, will see the cost fall as product design becomes faster and easier. However, there will remain plenty of differentiators in terms of sensing to provide a healthy market for mid and high end manufacturers.

Be aware that the growth includes the transition from wired products to wireless products. The five times growth in revenue across the five years is exaggerated as it reflects customers buying replacements for their wired products. However, these are likely to be more expensive, so there is a real revenue gain for the companies who can profit from that transition.

These numbers only look at the market value for hardware. Up until now, audio content has largely fallen into two simple categories – buying specific tracks or albums, or streaming as much as you can hear. As hearables gain greater processing capability and two way communications we're likely to see intelligence being added which may affect music content provision. Companies like Audiowings [67] are looking at the benefits of connected headphones, trying to understand how to use the knowledge of what we listen to and when to provide contextually aware audio experiences. That's a layer of knowledge that takes us a long way past the fairly simplistic concept of playlists which we have today. There's much room for innovation in this area. I suspect we will hear more of these companies as they attempt to license their intelligent hearing platforms as capable hearable devices arrive on the market. It is fairly certain that service models will evolve along with hearable devices. Who will benefit from that revenue stream is yet to be seen.

## **Challenges**

Despite the momentum we've seen, the hearables market is still finding its feet (or should that be ears?). Even Apple has had to delay the launch of their AirPods, which illustrates that we are on the bleeding edge of what can be done. Anyone entering this market needs to be aware of the challenges.

## **Technology**

As most of the early crowdfunded companies have discovered, making hearables is not an easy task. You need an understanding of wireless, batteries, power management, sub-miniature product design, design for manufacture, codecs, digital signal processing and audiology. That's before you add biometrics. I have seen companies fail where they have only had to tackle one or two of these, so it's no surprise that the average delay in shipping earbuds is over 13 months from the promised date.

There are some basics which have caused problems, the first of which is having two separate earbuds. The brain is remarkably sensitive to the arrival time of sound at both ears. If left and right signals lose synchronisation by more than around 30  $\mu$ secs the effect is disturbing. Current Bluetooth specifications don't support this degree of time synchronisation (future ones will), so vendors need to work out a way to manage this. Most products on the market use a proprietary solution developed by CSR (now part of Qualcomm), but this relies on wireless transmission between the left and right earpiece. Unfortunately, the head is a very efficient absorber at 2.4 GHz, so unless an earbud has a large antenna, this may fail. Companies have resorted to relying on reflections from walls (fine until you go outside), alternative wireless links, mainly Near Field Magnetic Induction (NFMI) [68], or in Apple's case, having a design which moves the antenna away from the ear and closer to the jaw, where left to right attenuation is far less of an issue. We don't know whether Apple's solution was engineering led or just a happy accident, but it is an elegant way around the problem.

Adding sensors is also problematic. Although the ear is a good site, sensors work best when in intimate contact with the ear, which impinges on the mechanical design and wearing comfort. They also eat into the power budget. It's telling that Bragi believe that removing most of their sensors from their second hearable may result in a doubling of the battery life.

Battery technology remains key. Hearing aids generally use primary Zinc Air cells. These provide a good power density for their size, but need regular replacement – typically lasting around a week. Almost all consumer earbuds have taken the route of rechargeable batteries. They're larger and are generally giving a battery life of only two to three hours. That's led to manufacturers supplying small charging cases which allow a user to recharge their earbuds during the day, prior to recharging the charging case overnight. Apple has done a particularly elegant job with the Airpod, designing a very small case which encourages users to replace the Airpods in it whenever they're not using them. Combined with the Airpod's intrinsic design, which allows a slightly larger battery, it's the first earbud / charger which can realistically offer a day's worth of battery life.

One reason hearing aids last longer is the attention which has been given to power management, along with the fact that most don't stream audio. That's changing and the new Bluetooth specification is being designed to try and add functionality without a major hit on battery life. However, the new demographic is unlikely to want to change batteries, so we will see more emphasis on the use of rechargeable batteries. Because of the complication of recharging such small devices, a number of companies are working on wireless charging, the most advanced probably being Humavox [69], who have a solution with ON Semiconductor. Wireless charging is particularly challenging for devices which are this small, so there is plenty of scope for innovation.

Charging may also result in an early concentration on over-ear or tethered earbuds for industrial markets where ear protection needs to operate for a full working day. That sector may push the development of wireless charging, as that may be a safer proposition to ensure that a device is ready for the next day's work. In contrast to earbuds, headphones have the advantage of more space – a lot of battery capacity can be hidden in them, but users still need to get used to charge them. One challenge for hearables in general is the total number of devices a user is prepared to charge each day.

Sound quality is being addressed by innovation from the transducer companies who supply by the

wireless headphone and hearing aid markets. In the last few years we've seen far more high quality microphones and speakers, a trend which will continue as they see more value in this expanding market. Companies who previously made custom DSPs for hearing aids are also beginning to look at the bigger market opportunity, both in the hearing aid / PSAP market and earbuds.

One of the biggest challenges, which is frequently underplayed, is the design skill required to miniaturise earbuds. If you take a hearing aid to pieces there is a lot of complexity and bleeding edge manufacturing processes within them. Large players, like Apple and Samsung have access to that specialised design tech, or at least the resources to acquire it. Most other start-ups do not. Whilst crowdfunding gives them the chance to play, it will become an increasingly non-level playing field. A lot has been made of the supposed Bragi – Starkey relationship which was announced at CES last year [70]. I'm not sure whether that was strategic or a personal investment by Starkey's CEO. However, others may want to test the same waters as a way of overcoming some of the technical hurdles.

A good indication that a technology area is taking off is the arrival of conferences dedicated to the underlying applications. There have been conferences on hearing aids for decades, not surprisingly, as it's a medical area. They've now been joined by new ones combining commercial and academic innovation in hearables design, the most recent being the AES International Conference on Headphone Technology [71]. That included sessions on headphone design, personalisation, binaural technologies, digital signal processing, noise cancellation and standards, with presentations from hearable manufacturers, component suppliers and academia. I suspect it will be joined by others over the next few years as the pace of innovation quickens.

### **IP**

Newcomers also need to be aware of their freedom to operate. There is a copious number of granted patents owned by the major hearing aid companies. Leading audio companies like Bose and Sennheiser also have large portfolios, the former being particularly strong in noise cancellation. Even lesser known are those from specialist startups who have been working in specific areas for the last decade. These include companies like Personics, Eers and United Science. There are many more "unknown" names out there who have IP which is only now starting to come to market. In recent years Apple and Google have been filing, although they may not have the depth of coverage to match companies who have been working in this sector for a decade or more.

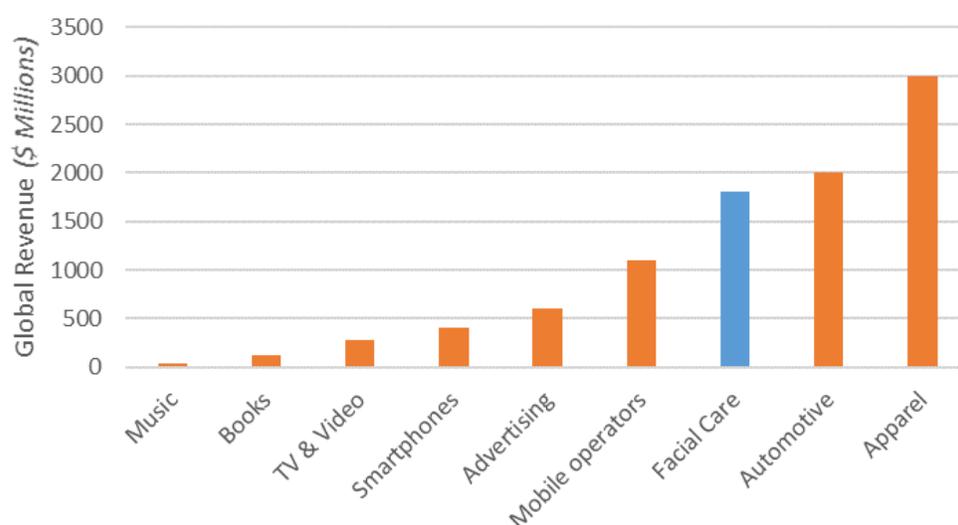
Crowdfunded companies often seem unaware of any of this, believing they are the first to have the idea. Some will certainly discover they were not, probably only at the point when they are at the wrong end of an injunction. Hearing Health Matters have been charting granted patents in this area since 2012, updating their list every few months. It should be mandatory reading for any company entering this arena [72].

### **Social**

There is another challenge to the market, which is more difficult to gauge, which is the social acceptability of wearing hearables. Hearing aids still suffer from a stigma, which is thought to be one of the main reasons why people put off acquiring them for so long. When a few companies introduced Apple MFI compliant hearing aids they saw a significant increase in sales, which suggests that the stigma may be diminishing, but we're not there yet. I would estimate that the early movers in earbuds

have shipped around 200,000 pairs so far, but I have still to see anyone wearing them in public outside an exhibition. Apple is better placed than any to change that, so it will be interesting to see how quickly people start wearing AirPods.

The challenge of all hearables is that in general, people consider their face as the most important aspect of their person. Helen may have had a face that launched a thousand ships [73], but would she have had the same effect on history if she'd been wearing an Airpod? The global market for beauty products aimed at or around the face, dominated by hair care, skin care and cosmetics is around \$630 billion dollars [74]. Add in designer spectacle frames, hairdressing and beauty salons and it takes the amount we spend on our facial beauty to somewhere around \$1.8 trillion every year. That's similar to the revenue of the mobile, clothing or automotive industries.



Sources: Statista, PwC, Lexology

**Figure 10. Relative sizes of global markets.**

Our desire to make the most of our facial looks suggests that a large percentage of the population may have reservations about some of the designs of hearables which we are seeing. That could be a barrier, but it should not be insurmountable. Glasses used to have the same stigma, but that changed and they're now a fashion driven product with an annual global revenue of around \$70 billion [75]. Already it's common to see people wearing wired earbuds and surprisingly large, branded headphones. However, any major mistakes in design could delay the market.

A more subtle concern is the social one, which is already being noticed. Once someone is wearing a hearable device, they often appear lost in their own world. When a hearable is just streaming music it's a fairly binary conclusion that they are not listening to you while they're wearing it, but are listening when they take it off. As we see more hearables which allow a blend of audio streaming and directed microphones, it's impossible to tell whether a wearer is listening to you or something else. Societal norms may have some difficulty in accepting this, particularly in the workplace.

Moving further forward, as we see Internet of Voice applications being integrated, there is also the

potential for users to regress into their own world of communication with the Internet. Sherry Turkle has already documented issue of social distraction from mobile devices in her book “Reclaiming Conversation” [76], but always-connected hearables could be the harbinger of an even more compelling trend to hide from real conversations. Time will tell, but the hearable industry needs to understand that there are negative societal issues associated with their products and attempt to design an experience which goes beyond short term sales.

### **Regulatory & Spectrum**

A final challenge comes from the regulatory issues around the cellular industry. Bluetooth and Wi-Fi both operate in the 2.4 GHz spectrum, which is free from license costs. As our demand for mobile data increases, mobile network operators are lobbying regulators to give them access to adjacent frequency bands. If granted, these will increase the level of interference in the 2.4 GHz spectrum, impinging on the ability of hearable devices to cope with interference. This will have a detrimental effect on the way that they cope with low latency and real-time streaming. Alongside this, various regulators are attempting to tighten some of the current requirements for wireless devices, updating the European EN 300 328 specifications, imposing greater demands on wireless performance, which will be difficult to achieve in such small devices.

These aspects of regulation are largely driven by telecom operators wanting more spectrum and Governments wanting to increase their revenue from licensing it. The hearables industry needs to become far more aware of the implications of these moves and make their voice heard. Otherwise they could find that regulatory changes limit the quality of wireless audio and the potential of their market.

### **Conclusion**

We started with the Airpod, so let’s end with it. One of the most interesting and least commented aspects of the AirPods are that they remain with Apple. Despite giving their new W1 chip to Beats, and despite the success of the Beats brand, they remain a headphone brand inside the Apple stable. Ownership of the earbud format, and by extension, the continuing iconography of the ear, remains firmly with Apple. Despite that, it still looks like an experiment. If successful, then we can see potential market revenue of tens of billions of dollars, but there are obstacles.

Of all the wearable markets, hearables feels the most real and the recent changes that Apple have made add momentum and substance to that feeling. It is also a market which has many different players – not just phone giants, but established companies in headphones and hearing aids who have the skills and experience to take and own large chunks.

That diversity has probably helped attract the number of start-ups, with the availability of VC investment and crowdfunding making it easy to innovate with hardware. That may be a short window of opportunity for them, but a very productive one for the industry as a whole.

Perhaps the most important driver is the demographics. Hearing loss is starting to affect a larger and larger portion of the population, no longer caused by natural ageing or industrial noise, but by self-inflicted habits. I’ll go back to Rene Tune-Svendson quote that the hearable market is just adding music to wearables. That is a very limited vision. Hearables provide the potential to own the spectrum of

hearing throughout our lives, reducing (but not removing) the damage from constant listening or loud music, changing the way we use sound and voice to interact with the world around us and ending up assisting with hearing loss. They provide the opportunity of owning one of our senses. Owning the ear for life is a particularly enticing goal, which is currently up for grabs. Over the next few years we will see which companies have the capacity to take it.

Nick Hunn

November 2016

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#### ABOUT THE AUTHOR

Nick Hunn is the founder and CTO of WiFore Consulting. For the past thirty years he has been closely involved with short range wireless and communications, designing technology that helps to bring mobility to products, particularly in the areas of telematics, M2M, smart energy, wearables and mobile health. During that time he has started two high-tech companies, both of which were acquired by multi-national corporations. In the big data arena he has been involved in the roll out of connected home energy systems which have collected trillions of domestic energy readings, working with data scientists to analyse these streams of personal information and introduce the energy sector to big data. He is currently working on accessories and hearable devices and chairs the Bluetooth Hearing Aid Working Group.

Nick has been closely involved with the Bluetooth SIG, the Continua Health Alliance, the ZigBee Alliance and other medical, smart energy and standards groups. He is the author of “The Essentials of Short Range Wireless” – a book attempting to explain the application of wireless technologies to product developers, and is currently writing a second book about the use of Bluetooth low energy for Accessories, Wearables and the Internet of Things. Nick has an M.A. from Cambridge University and can be contacted at [nick@wifore.com](mailto:nick@wifore.com). His blog, where more articles are available is at [www.nickhunn.com](http://www.nickhunn.com).