

The Market for Smart Wearable Technology

A Consumer Centric Approach

The consumer electronics industry has convinced itself that wearable technology will be the next big thing, with analysts predicting a market worth over \$30 billion by 2020. That belief is driven by a desperate need for major companies to find something to follow on from laptops, tablets and PCs all of which are being commoditised.

The problem is that their model for wearable technology is built around technology push, trying to shape their technology to fit consumers. It is a strategy that is likely to fail, as wearable technology is more, rather than less, personal. This report takes the contrary viewpoint, building the market opportunity from known consumer behaviour and preferences. It suggests the market will still reach \$30 billion in 2020, but with a very different mix of products being made by some very different companies.

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Introduction

There is massive excitement in the industry about wearable technology. Connected wearable products aren't new – they've been around in various forms for almost forty years. The pace quickened about a decade ago with the start of the quantified-self movement, but in the past eighteen months the arrival of new sensors and low power radio chips has transformed them. At the Consumer Electronics show in Las Vegas and Mobile World in Barcelona at the start of 2014, wearable technology appeared to have come of age. A year later at CES 2015 the story was only slightly more muted. Many companies had spent the intervening twelve months making copies of the devices shown the year before. Fitness trackers, smart watches, connected headsets, smart glasses, personal trackers and wrist bands were there in abundance. However, there was still no clear killer trend. That may have been due to the dampening effect of the Apple Watch launch offering “jam tomorrow”, along with a prescient concern about the future of Google's Glass.

None of that failed to dampen the enthusiasm of the industry, which is desperate for the market to take off sooner rather than later. Many analysts now believe that it will be the next major wave of consumer technology, replacing the love affairs of the last decade that have seen the success of laptops, smartphones and tablets. They are spouting phrases like “a technology tsunami” and “a revolutionary force” to kick-start the hype cycle. “The pace of change will never again be as slow as it is today” is the rallying cry, but will the pace of purchasing match that expectation? But are consumers ready?

The industry giants that have grown to serve these markets certainly need something new. It's easy to forget how many of the leaders of those industries have gained global prominence and then disappeared or have been badly burnt and withdrawn from the consumer electronics market to concentrate on other less aggressive areas – amongst them major names and brands like Nokia, IBM, Motorola and Compaq.

Today commoditisation is the curse that the current players fear. Laptops, tablets, even smartphones are no longer the next great thing. For most purchasers, they're just something we have and use, replacing them when they wear out or fail, like light-bulbs and socks. As smartphones and tablets look more and more alike the only differentiator is price, hence the desire to find a new market to invigorate the behemoths of the consumer electronics industry.

Large companies are fuelling the hype cycle as they rush to outdo each other. Before its announcement, the promise of the Apple Watch spurred Samsung, Motorola, Asus and others to up the pace of the technology treadmill, launching smart watches faster than a user could bare their wrist. The Apple announcement acted as something as a damper on their enthusiasm and probably gave the pre-emptive wrist-grabbers a lean Christmas. Nevertheless, as the smart watch star dims for the time being, more strategic announcements, such as Xiaomi's multi-million dollar investment in Misfit [1] and Valencell's threefold increase in licensing revenues [2] have managed to maintain the momentum of the hype cycle.

Fuelled by of the enthusiasm of the big players to embrace this market, analysts are falling over themselves to define and inflate the size of the wearable market opportunity. It certainly provides promising new revenue streams as manufacturers apply their expertise to a new range of products.

However, I am not convinced that these analyst projections reflect the consumer appetite for wearable technology, rather than replicating models for previous generations of consumer devices on the assumption that the average consumer will buy whatever they are offered.

I have the good fortune to travel the world, speaking at conferences and working with many technology companies. It gives me the opportunity to look at the penetration of wearables in different markets. At tech conferences in San Francisco or San Diego over 50% of the audience wear some kind of connected device, almost exclusively wristbands. At similar conferences elsewhere in the world it's around 10%. But when you look at the general public's wrists you see a different picture.

As a final data point for this report, I sat on Highbury and Islington train station during a July morning rush hour and looked at how many people wore some kind of smart device on their wrist. It's a busy interchange station in central London, two stops away from Silicon Roundabout with a young demographic passing through – exactly the one which wearables' marketers are pitching to. Out of 1,000 wrists only 183 were wearing watches at all, of which one looked as if it might be a pebble. There was one other person with a Fuel band, but that was the extent of visible wearables. Not 10% or 50%, but 0.2%. That's one of the problems with much of the market analysis – it's still a very introverted, incestuous community of developers, analysts and founders, which makes it difficult to see or predict the wider appeal.

The press coverage following Sony's recent stealth crowd-funding campaign for their e-ink FES watch [3] is a classic example of how the hype machine works. It was conducted under the auspices of a sub-group called Fashion Entertainments to gauge interest in the concept. It certainly got that, when it was made known that this was a group led by Hiroki Totoki, who heads up Sony's smartphone efforts. What none of the media stories mentioned was the fact that the FES campaign had only received pledges from 137 people before the media went ballistic proclaiming it to be "an overwhelming success". Such is the measure of informed analysis that is driving the industry.

It is telling that little is said that is meaningful about brand. In the desire to count numbers most analysts believe that brand is purely related to market share and revenue. Hence in their eyes the brand value of Sony in wearables is largely equivalent to Nike, of Intel to Google, even Apple to Samsung. They fail to make the distinction that owning and managing a supply chain has only a very limited correlation with owning a customer's desire, nor that owning the customer's desire is often different from owning the customer, which some of those names do very well. What most of the wearables industry is missing, because it is generally tech centric is the concept of mentality of Brand, by which I means that they fail to appreciate that Brand is different from branding. In that respect, perhaps the most significant announcement at CES this year was the collaboration between Misfit and Swarovski [4] to produce a solar powered version of the Shine fitness band. It uses a cleverly cut crystal to concentrate light on a photovoltaic cell, ensuring that the device never needs recharging. Whilst customers and techies might appreciate that, most customers will neither understand nor care about it. They will buy the Swarovski Shine because it is beautiful. They will then buy a second one or a new mount for evenings out because it's a different Swarovski crystal. And then another one for weekends; maybe one for the gym, and so on. Swarovski's promotional video [5] is worth watching. Whereas every other video for fitness and health devices is about numbers and charts on smartphones, Swarovski's is about the beauty of what you wear. Plus it is aimed at women who aren't sweaty all the

time. That is where wearables need to be, not just trying to be accessories to smartphones.

If wearables are to succeed, then the people I observed on the station are the people the industry needs to engage, not the high profile techies and their acolytes on the West Coast. It should be very possible to engage with that wider demographic, but only if the industry concentrates on what will appeal to them as opposed to what appeals to its members.

The belief that consumers will ultimately decide is driving this report. It does not just look at what is possible by applying technology to generate a new category of products, but tries to balance that with an estimate of what people will want to buy and why they would want to buy them. It shows that there is still a good opportunity, but potentially for a very different range and mix of products than those most analysts promote. It also looks at some of the technical risks and barriers to market growth, particularly with respect to market channels.

The full version of this report goes further [6]. As well as providing detailed numbers for each sector, it investigates the service models which will be enabled by smart wearables. They, and the revenue opportunities are further out – we need the devices first. But they may be the ultimate goal and revenue stream for the industry. If they can be made to succeed, then the wearable devices themselves may find themselves on a fast track to commoditisation.

What is a Smart Wearable?

Before looking at the segments in detail it is necessary to define a Smart Wearable, as the wider “wearable” name is applied fairly indiscriminately to many products. To be termed “Smart”, the wearable needs to contain active electronics, which may be a sensor, some form of haptic, audio or visual feedback, and also a way of communicating data via a wireless link. Wireless is there because most of these devices need to be self-powered, as a cord to power them or convey the data is anathema to the concept of easy wearability. At the most basic level, that excludes wired headsets, fitness devices that need USB cables to connect and LED T-shirts and shoes. Smart Wearables need autonomous connectivity. In other words real-time, or near real-time connections to send or receive data.

The “smart” functionality does not need to be provided by the device itself. Often it will be accomplished within the device the Smart Wearable connects to, i.e. the Smart Wearable does not need to be smart autonomously, but will have a local device or cloud application that consumes its data and provides feedback to the user, or which can send data to control its function.

Some of these products have existed for several decades. Both fall alarms and Bluetooth headsets meet this definition. That feels right, as we will see that both are the foundational products for sectors which take advantage of new technology to move Smart Wearable products forward. No particular wireless standard is assumed in this report. Whilst many will employ Bluetooth low energy for a local link with a smartphone or tablet, some, albeit a small minority, will use cellular, Wi-Fi, Thread, proprietary radio or other standards yet to emerge. At the point that a low power wide area IoT network becomes available, many of these sectors could double in size in a few years. Unfortunately such a network still appears to be at least a decade away [7].

The other deliberate constraint in this report is that it only considers products which are promoted to and purchased by consumers. That excludes many of the anticipated medical wearable devices which are regulated and prescribed. It also removes commercial products such as wireless call centre headsets which already sell in significant volumes and the whole gamut of professional wearable devices which are used in professions from mining to fire-fighting, surgery to parcel delivery and defence to warehousing. Wearables in the workforce are already making a mark. Although less glamorous, they are performing two very important roles: testing the technology and introducing some of the more socially intrusive wearable concepts to the public. That may prove to be an important role for devices like smart glasses which have a social acceptability barrier to cross.

Google's recent realignment of their Glass program acknowledges that the consumer is not necessarily the best revenue source for new technology.

Nor does this report include some of the more outlandish or flippant wearable products which have been suggested, such as the Apple iSock – a wearable for your iPhone, which is so wonderfully described at the satiric Trapcruch site [8]. Whilst the iSock is not intended to be made, there will probably be other left-field products which do reach the market, some of which may even be successful.

It doesn't help that it's sometimes very difficult to know whether a new piece of wearable tech is a spoof or real. The line between the sublime and the ridiculous can be vanishingly thin. Just compare the iSock with Sensoria's smart socks [9], which provide information about how you walk. Going back ten years, the Forgetmenot GPS panties of 2005 were a spoof [10], albeit one which collected many real expressions of interest. Products like the Pavlok [11] – a wristband that coaches you by giving an electric shock, opening up a new market segment of what has been described as "Coercive Tech" [12] appear to be real. With obvious references to Pavlov, the Pavlok ticks the box of bringing behavioural science to wearables, but it feels that it owes a little too much to Milgram to become a mass market. Then again, it may provide the ultimate proof of his theories, which ethics have prevented him and his protégées from testing.

It is incredibly difficult to identify how far consumer taste will bend under this onslaught of new technology. Throughout, the desire is to identify what a consumer would want to buy rather than what is thrust at them, which is likely to mean that successful products must have a significant degree of emotional attachment. Wearable is first and foremost personal – far more so than anything the industry has done before. That may not align with the current hopes of the consumer electronics industry, whose members are desperate to find new, high volume wearable products to push into the market, hoping they can mould consumer opinion to what they want to manufacture. I believe that for Smart Wearables to succeed there will be a need to generate far more consumer pull than has been the case with any previous consumer electronics sector.

Why Consumer Electronics is at a Crossroad

As mentioned above, the consumer electronics industry is in an uncomfortable position. Whilst it's not fair to say that consumers are falling out of love with technology, they're doing something which the industry finds profoundly disturbing – they're reaching the point where many of them find their current purchases adequate for their needs. For almost twenty years the industry has relied on Moore's law

to provide increasingly complex functionality that in turn has driven differentiation, pushing users to upgrade faster and faster. The emergence of new market makers – in particular Apple, has led to an increasing commonality of appearance which in turn has destroyed that differentiation and made it more difficult to produce a compellingly different product. The result has been a relative decline in consumer spending on hardware, which is reported to be falling by around 1% per year [13] for segments that traditionally always wanted the next new thing.

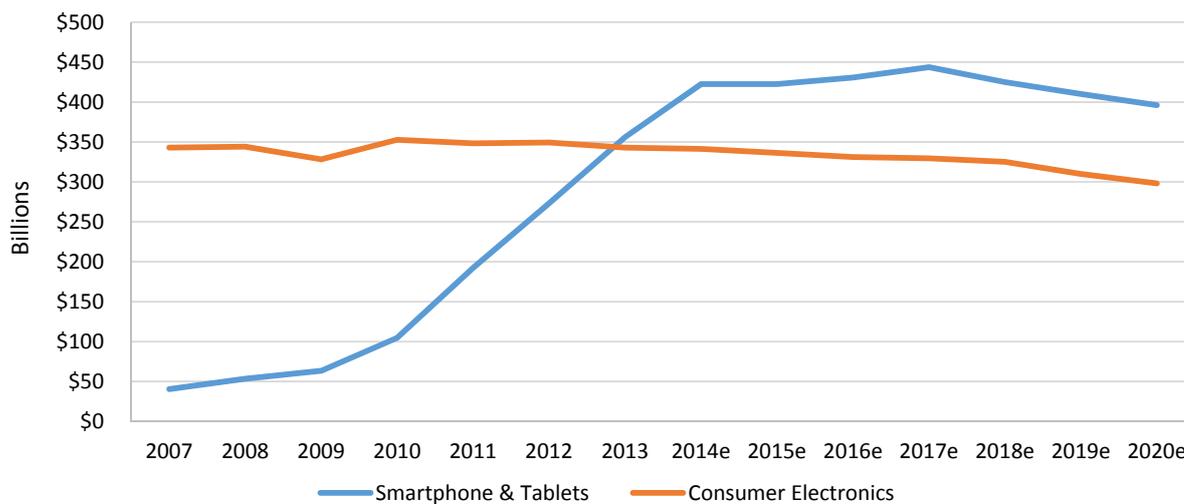


Figure 1. Global Market revenue for CE and Smartphone / Tablet markets

Figure 1 shows the dilemma the industry is facing, using numbers and estimates from IHS [14]. Since 2007 there's been a steady downward trend in spending on consumer electronics. However, consumer spending has poured into smartphones and tablets, recently overtaking the entire consumer electronics spend. The projections suggest that's not going to last. Although it won't disappear, it's reaching a plateau and is likely to fall over the coming decade, mirroring the static consumer electronics revenue. The industry is desperate to find the next big thing which can replicate the same growth. An equal concern is Apple's dominance in revenue, if not in units sold. This year Apple will overtake the PC industry with sales close to \$200 billion, despite having only around 10% of total smartphone sales. That's not likely to change in the near future as all of the competition gets squeezed.

A large part of this problem for the rest of the market has been due to Apple's success in changing the consumer perception of what technology can do for them. I choose the words carefully, as Apple's success is a result not just of brilliant consumer experience design, but also an unerring ability to make another industry segment its slut. It's not clear how it can accomplish that second feat for a fourth time, nor whether it is even possible in the wearable sector.

Let's look at how Apple has done so well. In the case of music players, smartphones and tablets, Apple did not invent the product. In each case they combined exquisite product design and marketing with an ability to usurp ownership and revenue from another service provider. In the case of the iPod, it was iTunes which took away revenue and power from the music industry. With the iPhone, the network operators were similarly emasculated, pandering to the iPhone's voracious data requirements

with little opportunity to become anything other than a voice and data pipe. As apps developed for both iPhone and iPad, Apple effectively created its own new service industry of application development with the AppStore, which they milked as a revenue stream whilst competition drove the profit away from the majority of App developers who flocked to it. Apple Pay may be their next success, but making it so could prove to be their biggest challenge so far.

There is a common theme. Each time Apple has applied themselves to a new product sector they have managed to acquire much of the profitability of the service providers within the sector. In contrast, competitors have only been able to function as hardware manufacturers. Those who have fought to match Apple's device sales have, so far, largely failed to usurp any of the content providers, giving them only one revenue stream – that from increasingly commoditised hardware, leaving them with an unequal struggle for profitability.

Ben Thomson, who writes on the market dynamics makes an interesting observation about this change [15]. Whilst many consider Apple disruptive, he disputes that definition, describing their products as "obsoletive". Without exception, their new products are released on the market at a higher price and offer more functionality than existing competing ones, making the other players' products and business models obsolete. It's possible because Apple can access new ongoing revenue streams which are enabled by the new functionality, supported by the critical mass of selling tens of millions of products. Having cornered the market, Apple can fund the next round of the ongoing game with another obsoletive generation of hardware. The question is whether Apple has managed to pull the same trick again with their watch? It is still much too early to say.

If wearable technology is to be the next consumer electronics' battle ground someone will need to invent a service model, as today wearable technology is still predominantly a hardware sale. As we will see, it is questionable how a pure hardware model will scale for wearables. Nor is it clear that there is a wearable equivalent of an apps store from which anyone can take a decent cut.

We'll return to that point again. Unless new service models can be found, Smart Wearables may elude Apple and others in that sector. Does it matter if Apple, Samsung and their peers fail in the wearables market? Possibly not, as there will be no shortage of new entrants, but the existing CE vendors have the marketing reach and supply channels to accelerate growth. A more organic growth from new entrants would slow adoption by several years. On the other hand, if the Apple Watch slips or its sales falter we may see stagnation from the heavyweights as they wonder what to do.

There is another risk. The prevailing mantra is that it's never been easier to design hardware. That is indisputable – you only need to look at the level of funding being pledged on Kickstarter and Indiegogo and the associated level of interest from angel investors in new hardware start-ups. But that doesn't mean it's any easier to become a viable, scalable company. A significant number of crowdfunded projects feel as if they will not progress past being large scale makers. That will not sustain the Smart Wearables market for long.

The crunch point for many will come in 18 – 24 months' time. That coincides with the point where larger manufacturers will start to decide which of the start-up products have the potential to grow to mass market. Should they decide to pursue these, they have the muscle to disrupt the initial disrupters. So any current start-ups need to keep a careful eye on these trends to decide when to aim for an exit.

Their market valuation is likely to peak sometime in 2016 or 2017. At that point, hardware disruption will become much more difficult – it is a narrow window of opportunity for founders and investors.

There is one interesting area of speculation about the future of wearables, which is whether or not they are accessories to smartphones? Today the industry seems to think they are. That may be a short term perception which comes back to bite them. If wearables really manage to engage users there is a risk that the smartphone becomes the real accessory. As we will see, hearables and other wearable devices will become more capable and more autonomous. If fashion brands can embrace and manipulate them the smartphone's star may begin to wane. That's a threat to the phone companies currently trying to promote wearables. Wearable devices could be the Trojan Horse which heralds the end of our current love affair with mobile phone.

Service Models

Discussion of the importance of service models is remarkably light in most analyses for this market. Look through the multitude of reports and you will see figures almost exclusively dominated by hardware sales. To a large extent the numbers in this report follow that trend, but highlight the service opportunities. The full, published version of this report contains predictions for the service revenue for each of the product sectors in this document. Overall they are comparable for the revenue from hardware sales, with a prediction of \$20 billion in 2020 against hardware revenues of \$30 billion. If some of the more attractive services take off, they could produce double the revenue of hardware sales [6].

The question is in identifying those companies that might succeed? Today, wearables remains very much a hardware play and hardware companies have little experience of delivering successful service models. Equally many service companies have little knowledge of consumer technology, being based on need rather than desire. They have limited knowledge of the data analytics and consumer behaviour which will be required to underpin these new services. There are a few existing service segments outside consumer electronics which could be step up to take on or complement the hardware behemoths. But few of them touch on any aspects of the wearables market. Medical devices is the most obvious exception, albeit one which is fraught with regulatory issues. Like the evil Corporacy in Lionboy [16], many seem to believe that "Science plus Business equals Health", which is something that everyone will be prepared to pay for. That has yet to be proven. Vida [17], one of the few new health start-ups to attempt to put a value on consumer health models is aiming at \$15 per week, which feels high, albeit offers the equivalent of a personal health coach. My impressions of expense may be a European perspective, with a backdrop of social healthcare. But that highlights the fact that this sector suffers from being fragmented around the world, with major national, and sometimes even more local divisions based on the funding of healthcare provision. That may work against US and European health service companies, as we'll see later. Whether hardware vendors can step up to provide an alternative service offering in this or any other wearables service space is also very questionable.

The Insurance sector is another opportunity, where some wearable plays have already been tried, such as with health insurance and fitness devices. However, it's a limited size and has already hit many issues of user manipulation. Early experiments with compliance devices were thwarted, as many

subscribers realised they could stay inactive and still benefit from reduced premiums by putting their fitness monitors onto their children or dogs. But they have an existing subscriber base and some of the new entrants, like ComparetheMarket [18] in the UK have demonstrated an unexpected and highly successful level of innovation in customer engagement.

Then we have the mobile operators and cable providers. Despite having the best customer fit, they have a poor track record of selling anything other than airtime. For all of their branding, they have little customer loyalty and behave more like utilities than compelling service providers.

Retail payment and financial services normally fall outside the remit of wearables, and probably also outside the aspirations of most consumer electronics companies, although PayPal and Apple's iBeacons are gently probing some aspects of the opportunity. Apple's Apple Pay is an interesting, low-risk approach and could be a major influencing feature for purchasers of their smart watch. They're probably alone in having the customer base to get the market for new forms of personal payment to critical mass.

So where does that leave wearable service models? It suggests the industry needs to find new market plays. There is not an obvious, current service owner who can be manipulated or exploited to fast track the market. Instead the sector needs innovation, both in hardware and services if it is to grow. Whilst there's never been a better time for hardware innovation, it's more questionable whether that is true for service innovation. In the longer term companies will need to develop compelling user experiences, otherwise the market will plateau as users become disillusioned with just another piece of hardware. That is probably the major challenge for wearable technology – finding a way to keep us buying new products.

The challenge may not be the same as replacing or discarding older products. A fundamental difference between wearable devices and current mobile consumer products is that if they are fit for purpose we may want multiple products rather than replacement products. Consider the average consumer. They don't buy clothes solely to replace ones which have worn out. The ultimate prize for Smart Wearable suppliers will be when they can boast of their own equivalent of a wardrobe, chest of drawers or shoe rack in every home, as consumers clamour to be the Imelda Marcos of wearables. However, the concept of selling multiple products with multi-year lives to a single consumer is a major mental leap for most CE companies.

Market Segments

Enough of the background. What are the opportunities? I believe that there are five distinct segments:

- Sports and Fitness – today the most high profile sector, as exemplified by the Fitbit, etc.
- Hearables – the evolution of earbuds from sub-\$1 accessories to high price tag, desirable lifestyle devices.
- Personal Medical and Assisted Living – the slow burn evolution of personal health products for the worried well and independent living.
- Kids and Pets. Whatever W.C. Fields may have thought about working with animals or

children, it may be the segment that elevates wearables to a mass market.

- Fashion. Wearable tech for the sake of wearable tech.

In addition, there the two jokers in the Smart Wearable pack:

- Augmented reality, whether that's Glass or other offerings, and
- Smart Watches, although this may be predominantly the Apple Watch. It's the segment which the industry wants to believe in most, but may turn out to be the black hole of consumer wearables, or not a watch at all.

What are more difficult to identify are the service models. If they emerge it means that hardware will be given away or leased, similar to the model that has served the mobile network operators. The increasing interest in the circular economy [19] may speed that. Already we see companies like Mud leasing jeans, apparently successfully [20]. But there's a long way to go before analysts stop defining the market by counting numbers of devices. The full version of this report [6] attempts that task.

Sports and Fitness

There is no doubt that sports and fitness trackers have helped to kick-start the wearable technology trend, from born-again pedometers such as the Fitbit and Nike+ to the rash (no pun intended) of wristbands. NPD Group believes that the total fitness market recorded sales of \$330 million in 2013 [21], dominated by Fitbit, who were responsible for 68% of US sales. Their survey reported that a third of consumers had heard of these devices and that almost a third of them would purchase one, with the largest segment of would-be purchasers being women who wanted to count calories. Future-looking analysts see this as a market which can only grow, assuming that the ready availability of wrist-worn devices helping us to be healthier will be an obvious purchase opportunity for most of the population. On that basis, we have seen predictions that the market will grow to between \$2 billion and \$5.1 billion by 2018 [22].

I think those numbers are fanciful. Just because a product can be made, does not mean it will be bought. There is no question about the appeal of these products to a minority of users, but I argue that they are and will remain a minority. I believe that we can easily identify the primary interested market segment, because it is already buying an associated product – gym membership.

Although I'm sure a fair number exist, I've only met one person with a wristband who doesn't go to the gym. The correlation is not really unexpected as both gyms and wristbands have targeted exactly the same demographic with the same message. Over the last year I've started asking everyone I meet with a wristband about whether they have active gym membership. I've been asking it of individuals and as a show of hands at conference and specifically asked if anyone has a sports wristband who is not a gym member. The one exception I've found is working on the wearables strategy of a major mobile operator, so may not represent a significant segment. So as a starting point I think it's fair to conclude that the Total Addressable Market for future devices should be limited to people with active gym membership. In the US around 19.5% of the population have a gym membership card [23]; slightly less in Europe at 12.5% [24]. In the rest of the world, even if you limit it to the middle class with disposable

income, the figure is only a few percent. There's not much indication that these percentages will grow significantly. However, that doesn't tell the entire story. Multiple surveys show that around 70% of gym members don't use their membership, or visit the gym fewer than three times in a year. Other forecasts of the market for sports and fitness wearables tend to ignore these realities of membership, concentrating instead on the current global estimate of just under 140 million current health club users. Even this figure is unrealistic, as it also includes social members who predominantly use the health club for food, alcohol and socialising and are unlikely to be purchasers of fitness devices. These false assumptions of the TAM indicate why the market potential for this sector is so often over-inflated.

Applying these corrections puts the global TAM as little more than 65 million potential purchasers in 2018. Even this is likely to be optimistic. It is a market that it should be very easy to sell to, but it will not generate the market of multiple billions of devices that most forecasts assume.

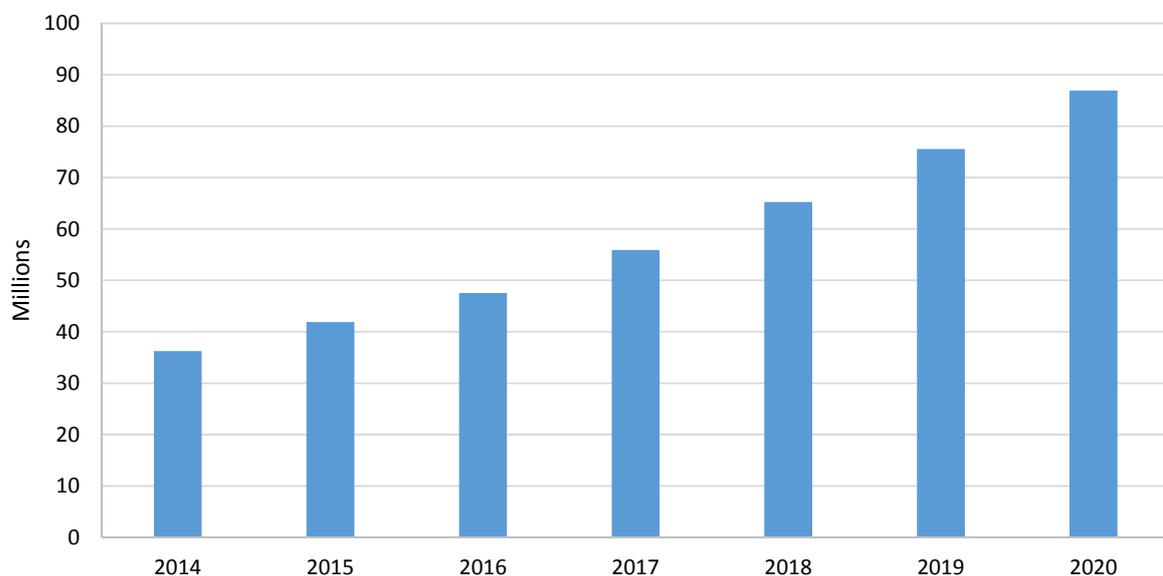


Figure 2. Total Addressable Market of Active Gym Users

You can argue that these devices extend beyond active gym membership by claiming that they become a virtual gym, but there is little evidence of that. There are some interesting opportunities for using them to move revenue from hardware towards recurring service fees. That should be easier for this market than any other, as it targets users who are already paying a monthly subscription for their gym membership. Companies like Cloudtag [25] are attempting to push that model. Gyms may embrace these technologies, but they need to be careful to ensure that they generate new, incremental revenue, rather than moving service revenue around whilst increasing hardware costs. The initiatives are worth watching, but they need to grow the total addressable market, not just tweak current models. I suspect that these devices may be decreasing gym attendance, which is another aspect to consider. My personal view is that time at a gym is time wasted - it's the penance for not exercising willpower or believing too much in celebrity shape. Smart Wearables may reinforce that view by persuading users to count calories without the subscription.

Another challenge this market faces will be to differentiate branded revenue generating apps from the

multitude of free apps which are likely to appear. If poor quality, free apps will devalue the hardware; if good they put pressure on any independent service model.

The market will certainly grow, but after an initial increase driven by the emergence of more competition and falling prices, this will be largely monotonic for this sector. I am intrigued by the reaction of an admittedly limited sample of fitness device owners; they either proudly state how many replacement units they have received because their initial purchases have failed, or else admit that they no longer use any function other than a calorie counter or the time. Neither is a good sign for market growth.

This brings us back to the fundamental question for the sports and fitness and Smart Wearable markets in general – is the device being sold as a sensor with the value being in a long term service model which may subsidise the hardware, or is it a desirable product in its own right, effectively maintaining the offering as a hardware purchase? Sonny Vu of Misfit, who I consider to be one of the more perceptive of the wearable industry's evangelists summed this up well when he said [26] that "Sensing is interesting but I think at some point people want you to 'do' stuff for them. We're looking to go beyond just sensing... I think wearables and smart home products can actually 'do things'".

The confusion about what these products are is exemplified by the backstory that Microsoft blogged when they introduced their Band [27]. "The path to building the band started back in 2010, when Alam (its co-creator) was the General Manager of Xbox Accessories. He was approaching 40, becoming less active and gaining weight. "I started wondering, 'What happened to the last 15 years?' and I had the embarrassing realization that I was getting really out of shape," he reflected. He was shocked into action when his father-in-law passed away unexpectedly in his 60s. Bilodeau (his co-conspirator and now Senior Director of Personal Devices at Microsoft) said, "I have to get in better shape. I don't want to die young. I have two girls at home." Bilodeau got into fitness and changed his lifestyle. He and Alam attended the same 6:00 am fitness class together, encouraging each other along the way. They learned a lot about fitness but also about the challenges of getting into better shape. From that experience came the Band and a personal realisation that "once you have a high-quality screen on your wrist, you can be more in the moment. I no longer need to keep taking my phone out of my pocket." I may be cynical, but I think that a company of this size that designs a product based on the middle-aged angst of a few of its managers has lost the plot and is not the place to look for a wearables strategy. Sadly, they are not alone.

The most popular and desirable personal devices in our recent past have been smartphones. They have largely been subsidised by a service model of network access, with cellular operators providing the smartphone at subsidised prices. Although users choose them for their application capability (which may reduce the operator income still further), the true cost is often hidden. There is no real clarity of who could duplicate this model for Smart Wearables, as unlike smartphones, they are not products that generate or replace a current service provided by a third party. The Apple Watch will be first good test of the potential market volumes for unsubsidised high-end wearable products. We need the first product to breach the ten million unit sales barrier to signal that the market is real.

The problem with any service model based on data from a Smart Wearable device is that it costs the service operator money and keeps costing them money for as long as the product is used. Service suppliers need to maintain servers and employ data and behavioural scientists to develop useful

algorithms that keep the customer engaged. Over the life of a fitness device the cost to suppliers may easily equal or exceed the original cost of the hardware. Today the early pioneers at the bleeding edge of the market can put a price tag on their products which supports this, generally with the hope that the product life will be limited. Either the company goes bust, removing the obligation, or it is acquired, passing the problem on to a new owner with deeper pockets. For new start-ups which don't get acquired, it may well be the cost of support and ongoing service which eventually kills them – sooner than many might expect. It will be interesting to see how well companies can transition users into buying an ongoing subscription rather than trying to cover these costs from the hardware sale alone. Other sectors which have tried to offer limited free subscriptions with a hardware purchase have found it difficult to get renewals from more than a small percentage of users.

Most mobile operators are looking at wearables, often with thoughts of a subscription model, but seem unsure of the opportunity. Historically mobile phones were designed to make revenue for them and the appeal of mobility was so great that the customer didn't throw them away – they kept on using them to make more money for the operators. That's hardly the experience of most wearables, where keeping them being worn looks as if it may be the greatest challenge. Once they're relegated to the drawer, any service revenue grinds to a halt.

As low cost copies start to flood the market, competitive pressure will make it more difficult to sustain the current market pricing which subsidises the backend services and development. At this point the winning companies may be those which can exit hardware production and develop a service model to support a wide range of fitness devices. Although most wristbands today are still managing to maintain a retail price above \$100, which just about supports the service model, similar products, such as the recently announced activity tracker wristband from Xiaomi, are already shipping out of China for less than \$15 [28]. It's my belief that far more of these are being made than is generally reported. What's not clear is where they are going,

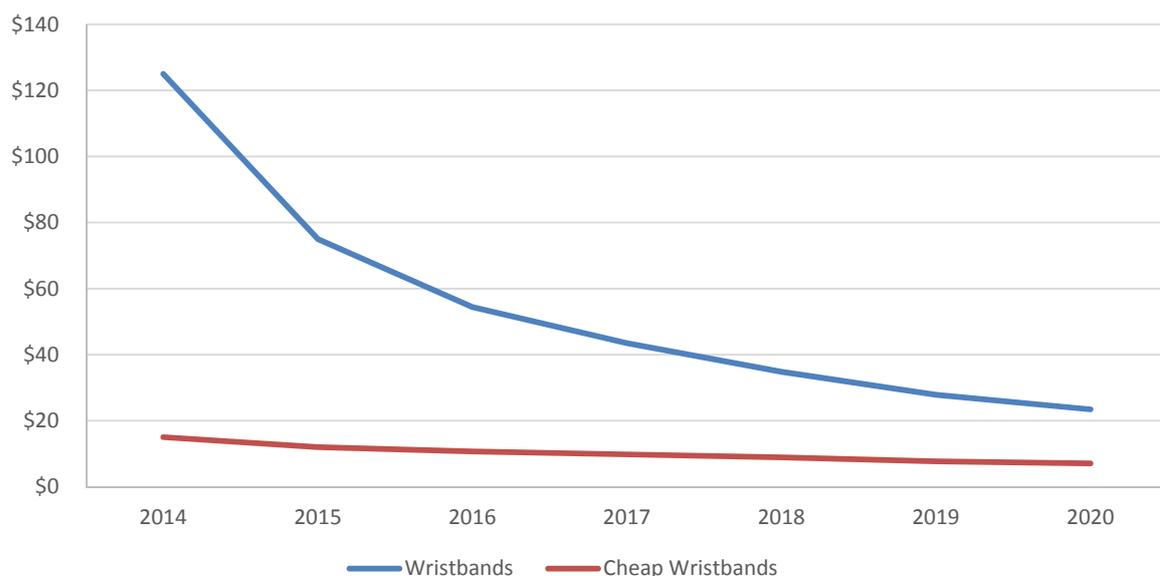


Figure 3. Relative price of branded and low cost OEM wristbands

Nike's withdrawal from the wristband market suggests that they already see this commoditisation and prefer to position themselves as one of the service companies. Other sports companies may follow, or decide to move upmarket to harvest the attractive margins of the semi-professional athlete, leaving the mass market to become a commodity play for what will become disposable products, largely relying on free applications. That echoes an observation made by Jason Jacobs, CEO of Runkeeper earlier this year [29], where he suggested that "most are on a road to nowhere. Like cameras and music players, their functionality will be integrated elsewhere, leaving the market to professional devices". Misfit has taken a contrary approach, partnering with Xiaomi to push their hardware. However, their positioning is more that of an object of desire rather than a sports accessory, which may allow them to preserve or enhance their differentiation.

It is not evident that any company has yet managed to commercialise the full benefits of software and data analysis. Most users still report that they stop uploading and looking at their data after a few months at best, reverting to the display on the device itself to provide the "nag" factor. Many early players have had a fairly traditional silo mentality, keeping data formats proprietary and making it difficult for other application developers to aggregate data. That has provided an opportunity for a number of Apps start-ups to offer compatibility and data aggregation across multiple devices from different manufacturers. Until the market moves to become more interoperable it may find growth limited. Although I doubt we will see a killer app, it is likely that third party developers will be the eventual source where compelling applications arise, stimulating market growth. Much more emphasis on data analysis is required to transform these products from fitness novelty to compelling application. Apple's HealthKit may help to force more interoperability, if only because the lure of selling to iPhone devotees is a strong incentive for product companies. If it succeeds, it will achieve what Google, Microsoft, the Bluetooth SIG and the Continua Health Alliance have all failed to do, despite them and their partners spending tens if not hundreds of millions of dollars in the effort.

This is not the only issue within the fitness market. Talking to the large OEMs manufacturing wristbands, it is clear that the companies selling them still slavishly follow the annual consumer hardware cycle. Products are designed for launch and volume sales in the Christmas period. That restricts consumer feedback to January and February, with hardware designs getting solidified during March and April for the next round. The cycle does not encompass software and data analysis, which seem to be tacked on. Physical appearance is still the major selling point, but even there innovation time is limited, as is testing, which has already resulted in some embarrassing product recalls. The current rush to compete for market share suggests there will be more faux pas, which will curtail market development by damaging user perception of the technology.

The timing of the Apple Watch announcement is a cruel blow for smart fitness manufacturers as well as competing smart watch vendors, as it impinges on their development cycles. Consumers appeared to be reluctant to purchase smart watches before Christmas having seen a glimpse of what is to come. Given its health and fitness features, such as the barometric sensor to count stair steps, many may have also held off from purchasing fitness devices. As a result, we're likely to see current products being heavily discounted in the coming months. Yet with the Apple shipment date after Easter (the latest date being given as April), the fitness market will have little if any time to copy its most popular aspects for their own Christmas 2015 offerings.

How do these issues affect a consumer-led market? Analysts report that around 2.25 million activity tracking devices shipped in 2013 [30] with a prediction of 10 million in 2014 and continuing double-digit growth. We've not seen the 2014 figures yet, but I suspect they may be seriously under-counting because they're missing the rapid growth in sub \$15 wristbands from the Far East. Commoditisation has already kicked in, largely due to the efforts of a few chip companies in pushing out reference designs. It's not clear where these are going, but at that price they can be given away to support a business or service, such as insurance, gym membership or dieting clubs. It means that volumes will increase to over 50 million devices in 2018. Despite that, the combined hardware revenue for fitness trackers and activity wristbands will stay relatively static at around \$800 million per year from hereon in, although annual product shipments could reach 75 million by 2020. The challenge will be for companies to extract recurring service revenues from these products. To do that they may need to take far more control of the direction of product development as fitness wearables morph into enablers of service revenue. At this point they become badged OEM products. Companies currently positioning themselves as product suppliers need to be careful about timing their exit plans. Nike's withdrawal indicates that this move is already happening. Whether it proves profitable is yet to be seen.

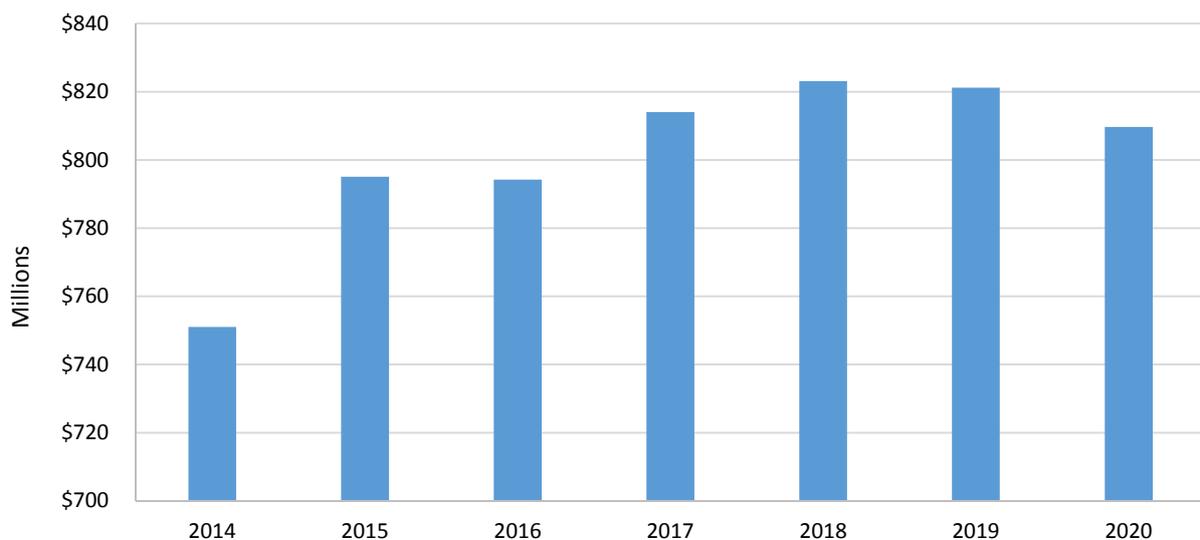


Figure 4. Global Market for Smart Activity Devices

(Data for all figures comes from the full report – *The Market for Smart Wearables 2015 – 2020 : A Consumer Centric Approach*, published Mar 2015. ISBN 978-1500578961 [6])

There are indications that some companies are starting to consider developing an integrated hardware / service play. One of the more interesting is Jawbone, who, following their acquisition of Nutrivise [31] is beginning to add dietary information to their current offerings. Dieting and calorie counting outside sports and fitness is already a well-developed application area. A lot of this is happening on smartphones, which are providing some basic activity tracking, but I've not seen much evidence of it growing as a separate wearables market. Jawbone's Nutrivise purchase implies that they're aware of the opportunity, but they need to get the form factor of the wearable devices right to make sure they

don't become a badge of being overweight. The last thing the industry needs is to create a product which is seen as an obesity band. For that reason dieting and the inevitable doppelganger of the anorexia band could play more to a smartwatch app assuming they can make the watch small enough. The problem here is that most smart watches are still men's watches in terms of size, which are not going to address the main dieting market. You don't need a degree in psychology to realise that dieting bands need to be the wearable equivalent of a Size 0.

We should not forget the long term success of Weightwatchers as one of the few successful, long-term service models in health and fitness, although even there, their ownership by a hardware company, assuming you can call Heinz that, proved to have a limited shelf life.

Smart Activity Clothing

Although wearable fitness devices are the most visible aspect of the fitness market today, there is a substantial sector of smart activity clothing. The simpler end of the market is running shoes, where the iconic Nike+ has defined the market. Although wristbands and other fitness devices can do far more, largely because they can place monitors in more intimate contact with the body, the shoe retains the advantage that it does not require any additional sensor to be worn, as you are already wearing it when you go out running.

At the high end of the market smart fabrics are creeping into sports clothing, providing detailed feedback about movement for professional athletes. These are currently highly specialised, as is the software analysing the data they produce. They're also priced at the professionally priced. Over the next few years advances in smart fabrics will start to reduce the cost and more importantly allow the creation of sports clothing which feels natural. At that point, smart clothing will begin to take over from fitness devices, thus emulating the running shoe, as the clothes we wear when we exercise will do the job of sensing themselves.

There are major challenges in the sports clothing market. Whereas one size of wristband fits all, the need for a good fit so that the sensor remains in contact with the body means that any item of smart sports clothing will need to be supplied in multiple sizes for both genders. To become the sensor of choice, it will need to be machine washable without the need to remove electronics or batteries. That will take time. It is unlikely that these problems will allow the market to grow significantly before 2018. Once these problems are solved we should see rapid growth, such that by 2020 the value of the smart sports clothing market will start to overtake that of stand-alone fitness devices. Again, companies who want long term revenue in this area will need to find ways of developing compelling service models.

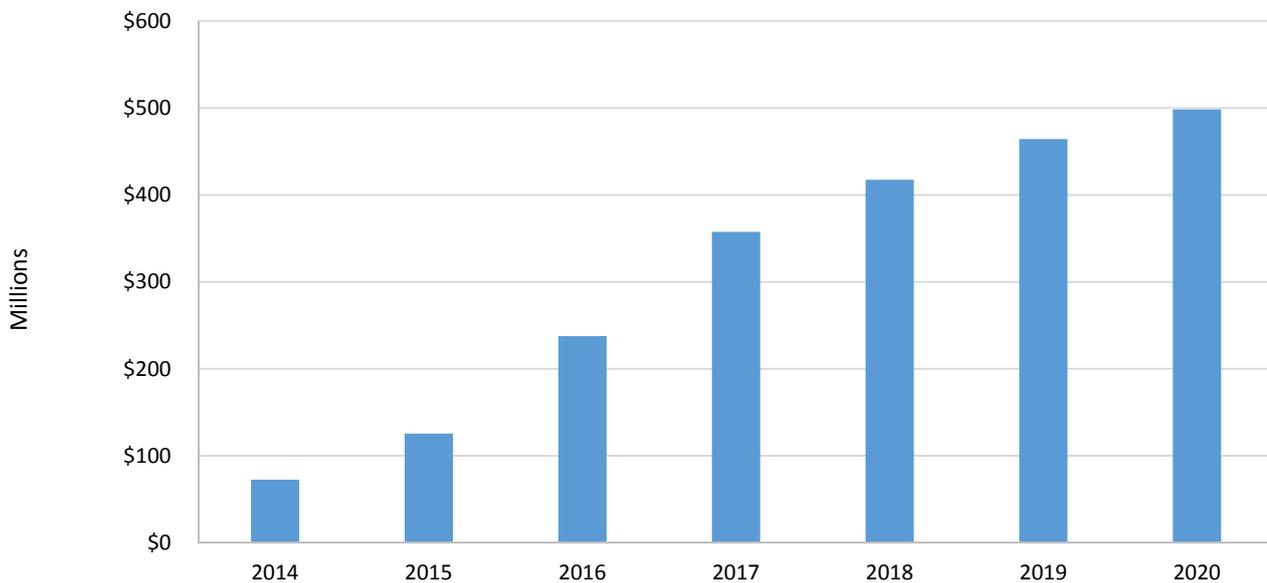


Figure 5. Growth of the Smart Sports Clothing Market

Some may be surprised by the high starting value for smart clothing, but this includes connected running shoes, which currently make up the bulk of the market. The rise from 2017 reflects new connected clothing starting to ship in volume.

It is debatable where the line should be drawn between smart sports clothing and smart fashion. For this report I've limited smart activity wear to that which is primarily worn whilst performing a sports activity. There are unexplored markets for branded smart sports clothing, where data from a global fan base could be aggregated and utilised during major sporting events. As these will be driven by social rather than fitness applications, they're covered in the fashion clothing section. At present they remain a wild card in the Smart Wearables market, as the technology to bring them to a mass market is still not quite here. When it is, they could dwarf the sports and fashion market, but that's unlikely to happen for at least four years.

Figure 6. Global Market Value for Sports and Fitness Smart Wearables

Overall the sports and fitness market for Smart Wearables looks set to grow to a hardware value of around \$1.2 billion in 2017, at which point it will start to plateau. Future revenue growth will be hit by commoditisation, but also by the arrival of sensors in clothing and hearables, which less dedicated sports enthusiasts are likely to prefer. Companies who want long term revenue in this area will need to find ways of developing compelling service models.

Hearables

I coined the term Hearables back at the start to 2014 [32] to describe the next generation of devices that we put in or on our ears. Whilst not yet the Babelfish of the Hitch-hiker's Guide to the Galaxy [33], a new generation of technology is going to revolutionise the way we listen to music, as well as providing an alternative to the wrist for vital signs and fitness sensors. What will drive this is a reduction in the power required for Bluetooth headsets, allowing music as well as voice to be streamed to a pair of headphones or a set of earbuds running on a small battery.

Think of the iconic iPod advertisements from Apple showing silhouetted figures with a pair of white cables going to each ear. Then get your black marker pen and scribble out the cables. That is how iconic hearables could be. Of course, manufacturers still need to make a product which is desirable – just because the technology is there doesn't mean anyone will buy it. The positive aspect of this market is that it appears the right type of innovation is already happening.

The other advantage of hearables is that they do not require the consumer to generate content themselves in any form – they continue to consume the same media that they are already consuming. As they consume existing content, which has an established service provision behind it, there is no immediate, new service model needed to establish a market for hearables. Instead manufacturers need to concentrate on selling them as objects of convenience or of desire. That does not mean that additional service models cannot be developed. Smart connected headsets are already available and it won't be long before they support services like Google Cast directly, rather than via a smartphone. And as new sensors are added to hearable devices a new layer of context aware music provision may blossom, along with audio lifestyle prompts, which may allow new service offerings to emerge.

The first products are already with us in the form of wireless stereo headsets from manufacturers like Beats Electronics. In the first half of 2015 the Munich-based start-up Bragi will start shipping its Dash wireless earbuds which include 2GBytes of memory for uploaded music. These also incorporate heart rate sensors to provide feedback for fitness users, removing the need for them to carry a phone or a music player. Bragi have taken the opportunity to open the programming interface of their earbuds to developers. That's a bright move for a product like this which should help it retain its retail price of \$299, as it will encourage a much faster rate of evolution of applications, maintaining the product's desirability. However, relatively few players can benefit from this approach against the inevitable tide of lower cost, compatible copies

The Dash, and other interesting ear-worn products which will soon be publicly announced, rely on the latest generation of Bluetooth chipsets which consume far less power than their predecessors, in particular one with a new audio processor from Cambridge Silicon Radio [34] which combines an advanced DSP with a major reduction in power consumption. For the first time this makes it possible to reduce the battery size for wireless stereo earbuds to the point where they last for a day or more. However, they still employ the same Bluetooth technology for transmitting music which has been in use for over six years. The next step in longer battery life will come in a few years' time, as the Bluetooth standards group is developing a next generation of ultra-low power audio technology based around its more recent Bluetooth Smart specification (formerly known as Bluetooth Low Energy). Products using this new technology, which should make Hearables even better [35], particularly in terms of extended battery life, will begin to appear on the market in late 2017, causing some major

transitions in product mix.

What makes hearables a very interesting sector is that it they use new technology to enhance an existing experience. That's a powerful combination for a successful market. The basic principles of hearables were established with the first real application of Bluetooth – the ubiquitous mono headset that allows calls to be taken when driving. Despite attempts to make it more fashionable, it has largely remained the distinguishing emblem of the cab driver. With an increase in the number of built-in carkits, the Bluetooth headset market has been steadily declining over the past few years. To counter that, silicon companies have worked to develop more efficient ways to transmit stereo music, allowing the design of wireless speakers and more recently wireless headsets. It is estimated that around 8.6 million of these wireless stereo headsets were sold in 2014. The leader in this market is Beats Electronics, which was recently acquired by Apple for \$3 billion, although other major brands reported significantly increased sales, suggesting that this is an area of wearables whose time has arrived.

Lower power consumption does not just make hearables more effective for audio. It also allows designers to add other capabilities. They're beginning to realise that the ear has potential beyond listening to music – it's an ideal site for measuring a variety of vital signs.

Valencell is an important enabler of many of Smart Wearable devices, making vital signs sensors which appear in growing numbers of them. Their CEO and cofounder Dr. Steven LeBoeuf made a prescient point back in 2011 when he wrote that "People everywhere are listening to music while running and exercising. Integrating heart rate sensors directly and seamlessly into music earbuds fits right into the behaviour of consumers today. Everyone's body responds differently to exercise, so being able to monitor the heart, the body's engine, will help consumers customize and personalize workout regiments for their specific goals whether it's for weight loss, toning or endurance" [36].

His company is one of a number that are working with hearable companies to add these sensors to wireless earbuds. As yet the applications are nascent, ranging from giving fitness information to inferring mood and hence selecting the choice of music. Once these wireless earbuds start to ship in volume, it will be interesting to see which applications gain traction. The sheer convenience of removing wires, (assuming that charging issues are overcome), suggests that these will become highly desirable products.

It is interesting to see the Bluetooth SIG working closely with the Hearing Aid industry on its next generation of audio standards. These aim to bring stereo music capability to hearing aid-sized devices which run on sub-miniature batteries, with little impact on the existing battery life. The hearing aid manufacturers have a level of knowledge in audio miniaturisation far in excess of that of most consumer headset vendors. That's reflected in the far higher cost of hearing aids, which is not just because they are medically approved devices. However, once chips become available after the new standard is ratified, this capability will be jealously sought for high end consumer audio products. The comfort of wearing such lightweight headsets will also destigmatise hearing aids.

That is a very important step for the industry. Facial appearance is extremely important for the majority of people – just look at the amount of money spent on rearranging people's hair (or trying to replace it) and make-up. As the popularity of the selfie has led to society becoming ever more concerned with facial appearance, anything we place on our head or face needs to complement the

image of ourselves we are trying to project. In the past, most facial health aids have stigmatised; the classic examples being spectacles and dental braces. In both cases the industry managed to reverse the image, turning them into objects of desire. When that happened, the revenues from new designer products catapulted the respective industries into a new league.

Whilst the stigma remains present, people are reluctant to wear a product until their medical conditions reaches the point where they have little alternative – usually well after the point at which they could benefit from using it. In the case of hearing aids, the industry believes that most users should have started wearing them at least ten years earlier. That would more than double the size of the market for what is one of the most expensive current wearable devices. We are already seeing the start of this trend. In 2014 Apple began to license a proprietary variant of the Bluetooth Smart protocol to hearing aid manufacturers, allowing them to build products which could stream voice and music from an iPhone as well as operating as a hearing aid. It is setting the stage for the arrival of the Bluetooth Hearing Aid profile, which will extend this functionality and bring interoperability to phones, hearing aids, TVs and public spaces. Along with a tranche of designer stereo earbuds, the perceptual difference between hearing aids and earbuds will soon disappear. The Bluetooth headset will no longer be associated with cabbies, but with celebrities.

Last year two major hearing aid companies introduced models which use a proprietary variant of the Bluetooth Smart standard designed by Apple which can stream audio and music from decent models of iPhones. Despite price tags that range from \$2,500 to over \$4,000 they have sold very well. What is particularly interesting is that these sales appear to be incremental ones, potentially from new users, illustrating that the destigmatisation process is already underway.

Although the foregoing analysis may seem obvious when you read it, some of the new hearable companies have struggled to convey the opportunity. “Nikolai Hviid, one of the founders of Bragi, reported that “We only had one discussion with an investor beforehand, and they didn't get what The Dash was about. "Who will need something like The Dash? What is the market for it? Who has made something like it before?" they said with scepticism. The Dash is a completely new category of product. It's intelligent headgear! People will see the purpose and beauty of it." We argued to no use. We had to trust our guts and proceed with the Kickstarter plan. But we had to turn our design and vision into something that was easier to communicate.” Bragi turned to Kickstarter and raised \$3.39 million, suggesting that consumers may have a clearer view of what they want in terms of Smart Wearable than VCs or leading Consumer Electronics companies.

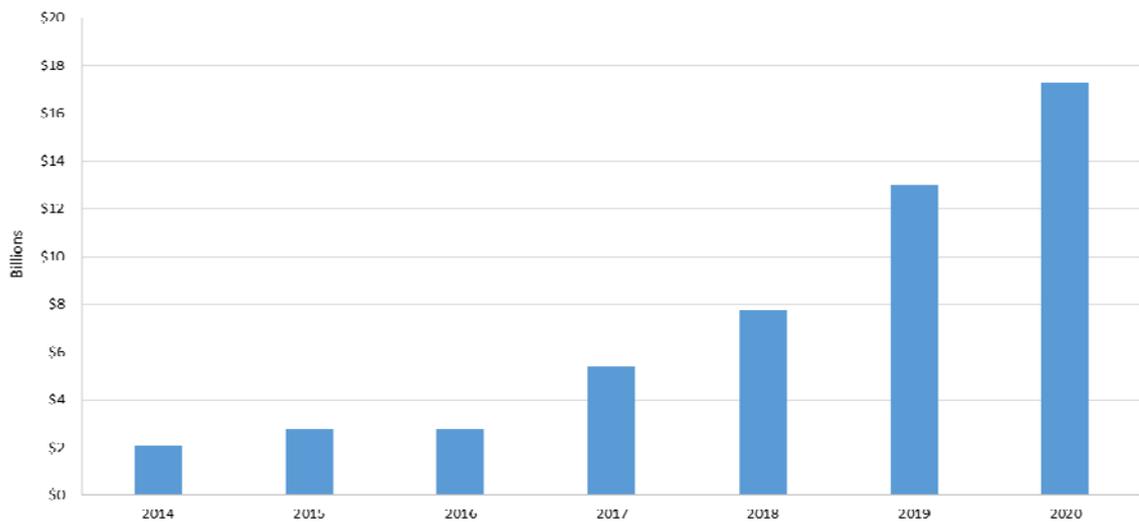


Figure 7. Global Revenue for Hearables

The hearables market already exists, but is in a state of flux. Bluetooth headsets volumes are falling and will continue to fall as the enforcement of laws against using phones whilst driving seem to lessen and more cars come with handsfree capability built in.

Wireless headsets are already making good strides in the market and will continue, along with wireless headsets more directly targeted at gaming. The growth in pre-Christmas sales suggests that they are moving from niche products to mainstream. High end models, like the SteelSeries H already command a retail price of around \$300. At some point these may merge into VR headsets, but that remains a wild-card outside this report.

Consumer adoption of smart earbuds will grow rapidly after 2017 when initial production issues are overcome and the prices start to drop. However, it seems unlikely that the price point will fall sufficiently to see them bundled with handsets this side of 2020. Instead, they are more likely to be a decoupled purchase, not least because they will increasingly be used with a diversity of music sources, including tablets, TVs and laptops to listen to content, rather than being restricted to just a phone accessory, which is what happened with the classic Bluetooth headset. Incidentally this diversity of audio sources suggests there is an opening for music services which place more intelligence within the headset in order to capture the full range of what a person listens to.

With the availability of Bluetooth Smart audio chips around 2017, the hearing aid industry will start incorporating these into their products en masse, with around 50% of hearing aids being Bluetooth based by 2020. The added functionality of these will also stimulate the market, although national reimbursement schemes through insurance and healthcare systems will mean the growth is likely to be slower than for consumer products. However, that may have the effect of increasing personal purchases.

Where growth will be explosive is in exploiting these chips in mid-range stereo headsets along with smart wireless headsets and earbuds. Although many of these will still be premium products they will grow to shipments of over 110 million devices in 2020.

Although the mix of hearable devices is changing rapidly, the overall hearables market value will be fairly static to the end of 2016 as the slowdown in traditional Bluetooth mono headsets continues. Stereo and gaming headsets will counter this decline, but there is a marked turnaround in 2017 as the new generation of earbuds start to ship in volume, which will then accelerate in successive years. By 2018 the hearables market will be worth over \$7.6 billion, after which it will accelerate to over \$17 billion in 2020, driven by the new generation of desirable hearing aids, making it the most significant Smart Wearable sector.

Before leaving hearables, it's instructive to look at the range of sensors which are being integrated into them, as it gives perspective as to just how much they will soon be able to do. Bragi have recently published details to developers of the sensors and derived data in the Dash Earbud, which they hope to make available in their API. Outside audio they include: accelerometer, pulse oximeter, heart rate, blood oxygen saturation, burned calories, body temperature, air temperature, distance run, steps, cadence, turns, speed, rotation, G-force and angle. There's also hint of gesture control, an audio filing system and microphones. They're not alone with gesture. Another hearables start up – Elbee [37] is promoting that as their hallmark feature. Developers need to start thinking about how to extract a compelling experience from this plethora of data.

This is not just a threat to the fitness market, but also the smart watch, both of which will need to prove why they should carry the cost of any health or fitness sensors once they've found a home in the ear.

We should not forget the importance of the microphone as one of the sensors in hearable devices. Today, outside hearing aids, where they are the *raison d'être*, their main use is in noise cancelling headsets. As the processing capability of hearable devices increases, companies are looking at them for other applications. Sociometric Solutions [38] listen to the way people talk for many clever medical reasons. But they also look at both speed of delivery and tone of voice to track employee interactions for companies [39]. Other companies are analysing ambient sound to add extra layers of metadata to location. Hearables are not just about providing sound, but also acting on the things we hear.

It's interesting to speculate where hearables may go? We are already seeing connected headsets which don't need a smartphone to provide content – they stream music directly from the cloud or rely on local storage. Soon we'll see them using the intelligence derived from their sensors to make music selections, monitor what we're doing and talk to us. Add gesture and you have an autonomous device which can be fashionable and desirable. Whilst I don't think that hearables will usurp the smartphone, they may take over a lot of its more personal functionality, particularly if the current trend for audio blogging extends to and becomes embedded in social media. It could be the first chink in moving from the smartphone as the primary device that must be carried at all times.

Personal Medical and Assisted Living

The problem with predicting growth in medical wearables is that the demographic most eager to buy them may well be prevented from doing so because of regulatory barriers set by the FDA and European authorities. Over the next few years we are likely to see a growing tension between fitness and consumer health devices and medical products as manufacturers attempt to sidestep regulations to

grab market share.

This report takes a very limited look at personal medical devices, confining itself to a few products which consumers are likely to be able to purchase directly. There is quite a narrow band of opportunity for products which fall between the sports and fitness category and those which are regulated and can only be prescribed by clinicians. That constrains this report to:

- Assisted Living monitors purchased independently – predominantly passive monitoring and geofencing
- Standard, connected medical devices bought by the worried well, as opposed to being prescribed, such as thermometers, blood pressure meters, etc. and
- Tricorder type diagnostic units

These only provide a view of the tip of the iceberg for smart medical devices. Despite that, a few years ago there was hardly any market for them. It indicates a growing desire from a segment of the population to address their own health.

According to almost every report you read, consumers want more and better health monitoring, although there are few proof points that they are actually prepared to pay for it or even use it. At the same time, regulators are under pressure from professional medical bodies to restrict access to any devices on the market to qualified clinicians. One example of this dilemma is the future usage model for the Apple Watch. There is speculation as to whether it may be used as a true medical device, fuelled by Apple's appointment of numerous experts from medical device companies, features described at its launch and their announcement of HealthKit last Autumn.

Although most consumer medical devices and apps sell themselves on the fact that users can stream data to their doctors, doctors are fairly universal in not wanting to receive it – it simply increases their workload for no additional financial return. Unless we see offshore health monitoring services, this is not as obvious a service model as it may appear. Connected medical devices have been around for many years. If the service models were so obvious we would probably already have seen some of them succeed.

The Tricorder Effect

Whatever the Apple Watch and HealthKit may enable, there is a more significant initiative that is poking the same regulatory hornet's nest. The Qualcomm Tricorder competition, named after the Star Trek monitor of that name is being run by the X-prize foundation [40]. It is an excellent initiative, but is likely to be a growing thorn in the side of regulators. It offers a \$10 million prize for the first team to design a product which can reliably measure five vital signs and diagnose 15 or more common diseases. Thirty teams took up the challenge and after a year's work the first ten finalists have been announced [41]. An element of most of these teams' approaches includes one or more wearable sensors. It is debatable whether a winning device will be developed in the competition's current timeframe, which is the end of 2015. However, there is little doubt that some of the companies participating will come up with products which fulfil a significant portion of the challenge. These will be immensely disruptive as they will herald the start of the obsolescence of the role of the General Practitioner. Whether they

save lives, or turn us into a world of global hypochondriacs is yet to be seen. However, they could be viewed by some segments of the healthcare industry, including big pharma, as a new opportunity, which might also presage some new service models for lifetime drug supply. Going back to Lionboy [16] – a refreshingly cynical story for children, the belief that Business plus Science equals Health is deeply ingrained.

In the US and Europe these devices will probably be banned from sale until they are approved by the FDA or the local regulator – a process that can take up to five years. Even then they will most likely only be available via a GP. Where regulation of medical devices is less prescriptive they may become spectacularly successful, particularly if they can achieve a price point below \$250. At this price it becomes difficult to see why it would not become a standard household purchase, particularly at the point where a family has children. Europe and the US then faces deregulation by attrition as they are personally imported via internet sales. Whilst the medical profession tries to stop them, individual online imports will flourish, probably supported by offshore data analysis services. It's a trend which may move much of the revenue for future personal medical Smart Wearables away from US and European companies. In the extreme case, the role of the GP could be made obsolete by medical diagnosis and health advisory services delivered from other parts of the world, leaving many doctors with a primary role as someone for lonely old people to talk to.

The most advanced company in the Tricorder competition in terms of public profile is Scanadu [42], which has already taken over 1,000 advanced orders and is on the cusp of shipping products. To circumvent the FDA restrictions they are requiring each customer to enrol themselves and their data in a medical trial. It's a nice loophole, but not one which will support a North American industry at any degree of scale.

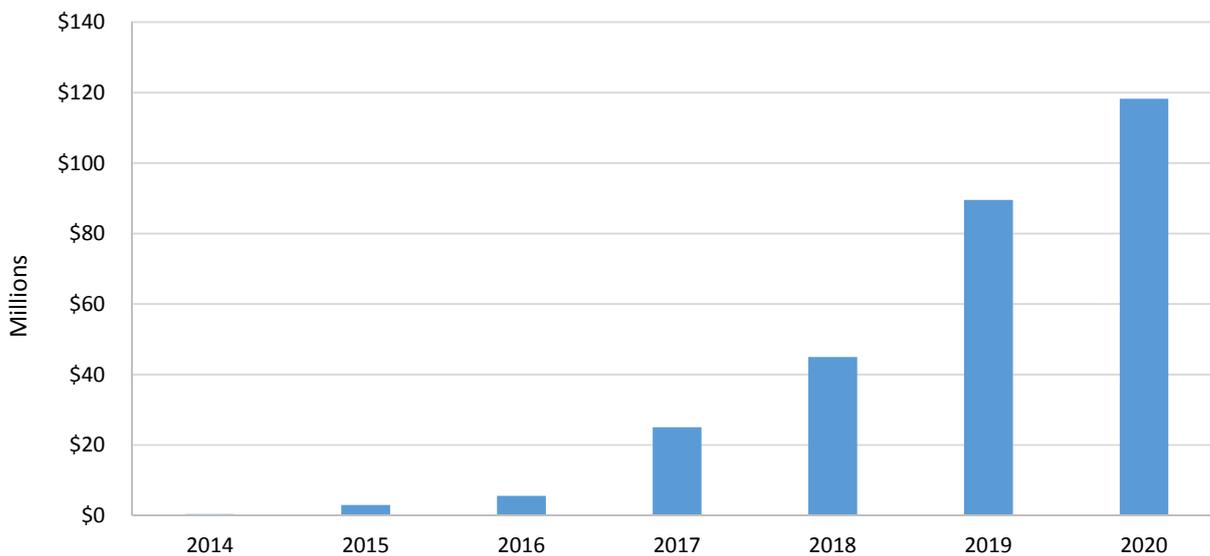


Figure 8. Global Sales of Tricorder based Products

Tricorder devices will need to win the public's confidence, but in many cases that barrier is small. The ability to instantly diagnose common complaints without the need for a doctor's appointment makes

them a very attractive proposition. The slow growth in sales reflects the difficulty in developing them, along with the fact that for several years they may need to be purchased online from overseas' suppliers. Unless regulators relax their views on these devices, much of the market will be outside the EU and US.

There is an interesting insight from Endeavour Partners [43] who have looked at the effect of human behaviour change in long term engagement for wearable devices. Within healthcare they saw a bimodal distribution amongst prospective users, with a distinct younger segment (25 – 35) and an older one (45+). The younger group were primarily interested in health around fitness and expected to use free applications. In contrast, the older cohort had a higher focus on improving their overall health and extending their life expectancy. They were prepared to pay for these services. In other words, preserving youth and preserving life elicit very different valuations.

Paying for anything purporting to be anti-aging is big business – the global annual market is estimated to exceed \$250 billion [44], driven by the fear of growing old or dying. Within a decade it could be larger than the value of the global consumer electronics market, which currently stands at \$340 billion and is declining year on year. It certainly offers massive opportunities for Smart Wearable devices, but will probably need to wait for the younger demographic to purchase less questioningly, determining what, amongst the serendipity of inventiveness, has the greatest lasting appeal. Globally, by 2020, around 1 billion people will fall into the category of “worried about aging with enough disposable income to try to do something to prevent it”.

The conclusion you can draw from the Endeavour research is that even with the same Smart Wearable there may be opportunities to segment the associated service models. Their report is one of the few that highlights the issues of engagement and is worth reading. I have long argued that successful companies in Smart Wearables need to understand data science and behavioural psychology and ensure these disciplines are represented in their core teams. If they don't understand the relevance of Fogg [45] and Cialdini [46] they are likely to fail. Endeavour Partners is one of the only analysts I have seen who echo that view. Unfortunately most technology companies have not extended their comprehension of behavioural analysis much beyond Pavlov.

Assisted Living and Personal Emergency Response Systems

Some might argue whether assisted living products should really be counted as Smart Wearables? However, fall alarms deserve to be here as one of the oldest examples of applying communication technology to things we wear. They also tell a salutary story. As a product category they've been in existence for over 30 years, but despite having one of the most obvious monetary benefits of any connected device for health providers, it is a market which has resisted most predictions of growth. It is useful to examine the reasons, as similar barriers exist in many other Smart Wearable areas.

Assisted living is one of those applications which everyone feels is eminently sensible, but suffers from being one that encompasses major barriers of stigma and guilt. Most elderly people defer the purchase of such devices until they have had a major fall or medical emergency. Even then, usage is typically low, either because current designs tend to stigmatise, or the technology does not fit the perceived need of the wearer. In countries where assisted living devices are supplied by government funded health and social departments, there are often issues of silo funding, where the cost benefits of

reducing hospital admissions are not reflected in the budgets of social care departments that fund the assisted living equipment. Because the products are often bought by procurement managers, it also means that they're often designed to appeal to these purchasers, not the people who will wear them. That alone is believed to account for over 30% of such devices not being worn. It's one of the many reasons that the growth of assisted living products has failed to meet projections.

There are some signs that this is about to change. The underlying demographic changes in population are set in stone – there are more over 60s alive than ever before; far more are living independently and there is are typically fewer people available to look after them. As a graphic example, the figure below shows how the population distribution of Scotland has changed from 1911 through the end of the last century to a projection just sixteen years in the future [47]. The same change in demographic is being seen worldwide. It is a startling illustration of both the problem and the opportunity.

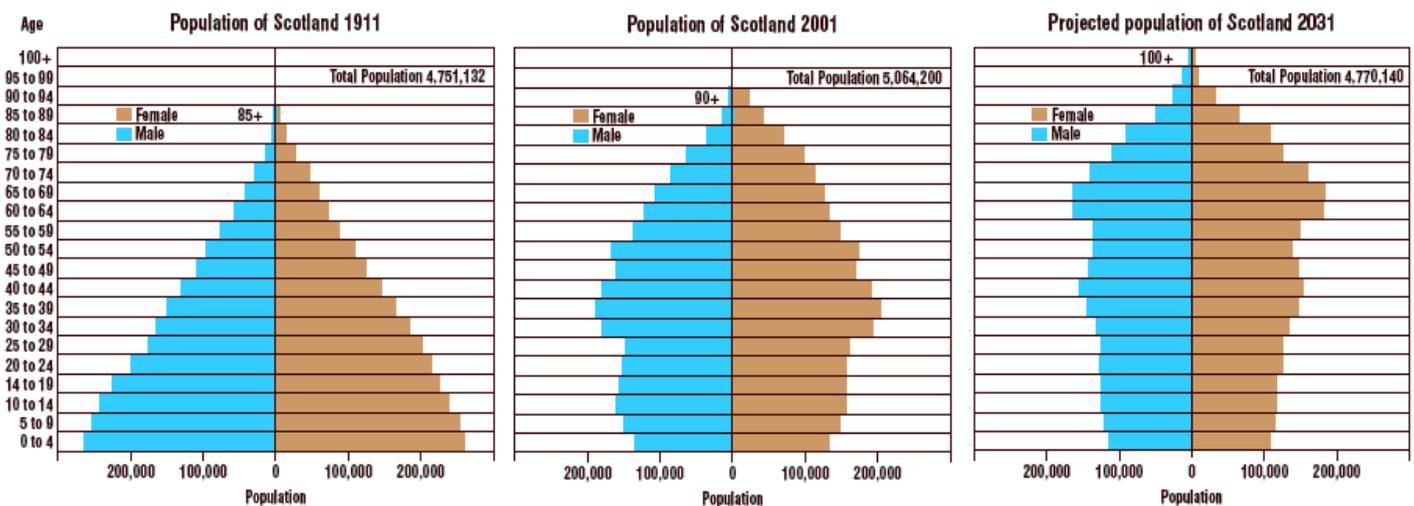


Figure 9. Changing Population Demographics (Scotland)

Longer life spans are starting to have some unexpected effects. Baby boomer couples retiring now generally find that they need to look after two sets of parents who are still alive, at the point where they had expected more freedom in their own lives. Regardless of whether or not there is state funding for assisted living, this is producing a demographic which is more likely to pay for technology to look after their parents, allowing them the freedom to enjoy the unencumbered retirement they had been led to expect. It gives manufacturers an opportunity to sell assistive living products and services to guilty children as a means of giving them the independence they had anticipated when they reached retirement age. The fact that this generation may have the best pension provision and hence disposable income of any in the next fifty years makes them an especially attractive market to capture.

The two major product categories which dominate this self-purchase model are described as Personal Emergency Response Systems (PERS). They are predominantly fall alarms, and geofencing monitors, the latter of which tends to be aimed at dementia wanderers.

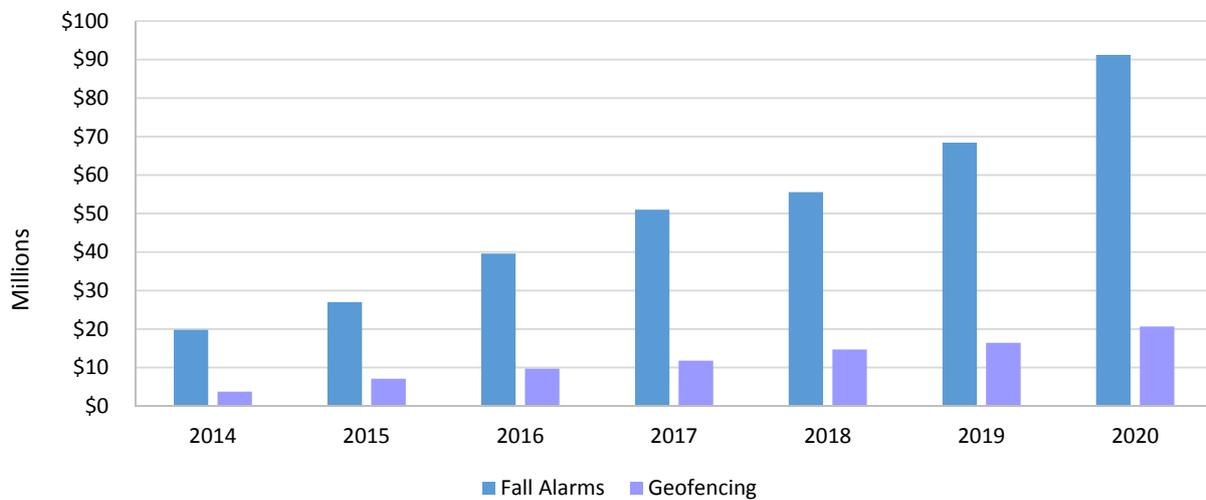


Figure 10. Global Market for Personal Emergency Response System Products

Currently most of these devices are funded by insurance or by Government health care schemes, which pay both for the hardware and also the monitoring service. Uniquely in Smart Wearables, almost all of these products rely on a monthly service subscription to alert carers in the case of an emergency. In many ways, that has been the biggest barrier to their more widespread use as the few companies in this market have long established B2B models with insurers and care providers and have shied away from implementing direct B2C sales.

Despite that, personal sales of fall alarms are starting to grow, largely financed by baby boomers who feel guilt at not wanting to have their parents live with them. The technology in these has historically been proprietary radio, but that is likely to change around 2016-17, as the other industry standards of Bluetooth Smart and Thread become available in home routers, lowering costs, which in turn will accelerate growth. That change accounts for the slight plateau in overall revenue in 2017-18.

Geofencing is predominantly deployed to guard against wandering in Alzheimer’s patients, alerting carers when users stray outside their home or find themselves lost and wandering. At least one company – Buddi [48] has taken the approach of selling these to the elderly as a way of stopping their children worrying, as opposed to the more conventional approach of selling them to the children to give to their parents. It’s an interesting reversal of sales model, which could result in a much larger percentage being worn, rather than being kept in a drawer. These devices are likely to remain cellular based over the timescales of this report, moving to low power M2M networks when they become more widely available, probably after 2023.

Traditional Connected Personal Medical Devices

Moving on, it could be argued that in some ways connected personal health devices, such as thermometers, sleep monitors, blood pressure meters and ECGs are not really wearable, but it is worth looking at them as the sensor technologies will migrate into many wearable products. Currently few of these connected devices are bought by users, as most come via doctors. Those which are purchased tend to be used more at the quantified-self end of the wearable technology market. These single function devices will face a very challenging market as new sensor technologies become integrated into other wearables.

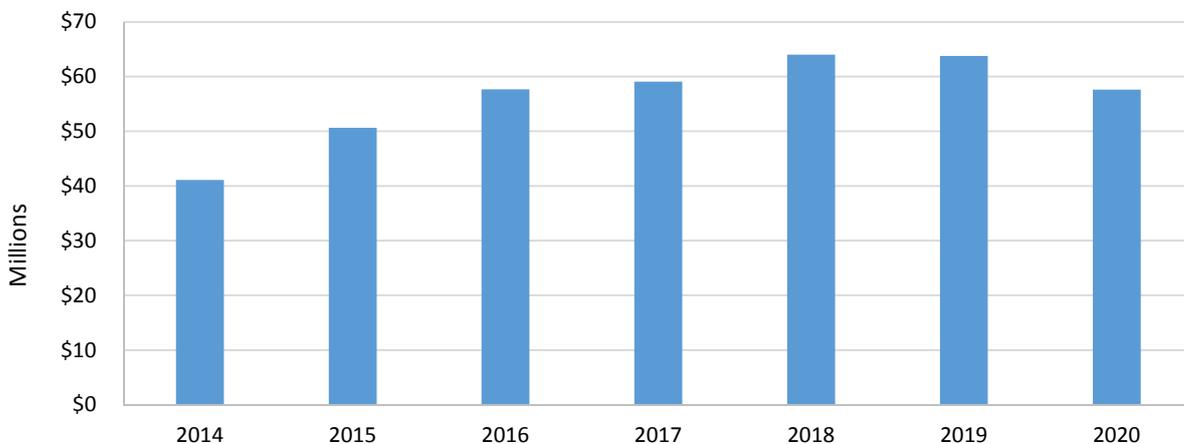


Figure 11. Global Market for Personal Smart ECGs, BPM, Thermometers and Sleep Monitors

As that happens, the market will face increasing pressure. It will be sustained largely by the tradition of devices which provide quantitative measurements rather than qualitative trends. The latter is more suitable for non FDA approved and long term monitoring, but needs to break the long-held quasi-scientific belief within much of the medical profession that the number of decimal places in a reading is important. Time and again, particularly in standards groups, doctors insist that accuracy is more important than repeatability, emphasising the traditional “snapshot in the surgery” view of medicine, despite all that is known about “white coat syndrome”. It’s an important distinction to emphasise. Wearable health should mostly be about trends and prevention, which is diametrically opposed to the GP’s favoured solitary measurement.

The trend for miniaturisation in sensors will see new measurement techniques, as well as the revival of older ones, such as ballistocardiography, which will benefit from new sensor manufacturing processes. As Tricorder type products begin to ship in volume, the market for single function “clinical-like” products will start to disappear outside the clinical environment.

For all of these personal medical products, other than the traditional single function vital signs monitors, service models should dominate. Once the hardware costs drop they might well subsidise the hardware.

Kids and Pets

“Never work with children or animals.” It’s a line that many in the wearable market may disagree with as kids and pets may turn out be the low hanging fruit on the wearables’ opportunity tree. The reason for that is twofold. Firstly, both are the recipients of things that they may not themselves want, but which are bought for and imposed on them by parents/owners who find that providing “the best” for their darlings is a justifiable expense. Secondly, because they are “loved ones” they are a particularly precious asset that needs protecting. That may sound cynical and mercenary, but the combined duo of guilt and fear which drive those use cases have been utilised successfully by other industries for many years.

Baby Monitors

Starting at the beginning, there is already a small but burgeoning market for wearables for babies. Decades of media scaremongering about cot deaths, have made new parent ever and ever more anxious about their new-borns, opening up the market for baby monitors. Traditionally these have been passive – often microphones or video senders which let parents keep an eye on their child, but which lose their effect once the parents themselves go to sleep.

A number of start-ups have recognised that this is the ideal opportunity for placing sensors into clothing which can monitor the baby’s vital signs directly and alert the parents at any time, night or day, if something appears to be abnormal. The best known is Mimo, which sells packs of three sleep suits with a connected sensor in the form of a small green turtle, which monitors respiration, skin temperature and movement, as well as allowing an audio link to a parent’s smartphone [49]. Owlet [50] takes a similar approach, but in the form of a connected sock. It is yet to ship, but offers the same level of protection. It also promotes itself as a way of checking on your baby when you’re at work or have baby sitters in. They currently retail for \$199 and \$250 respectively, so peace of mind does not come cheaply. Sproutling have an ankle band that does the same thing [51], reassuring parents that they can “make parenting less scary”. Their first batch sold out quickly and there’s now a waiting list for the \$299 monitor. Sensible Baby’s Smart One sensor [52] takes a more interesting (and possibly less commercial) approach of claiming to start the “quantifiable baby” trend. If, like me, you find the promotion of “sensible” worrying, I can recommend Brian Patten’s “Gargling with Jelly – the Play!”, featuring the dreaded Doctor Sensible [53] as a reliable antidote to the perils of overanxious parenting.

Baby monitoring is not medical, as there’s nothing wrong with the baby. The human population has successfully grown to over seven billion without them, so they are essentially a guilt sale, based on how you would cope with the criticism if your child died and you’d not bought one. It is effectively a hardware insurance policy for parental guilt. That’s why they have the potential to be extremely successful.

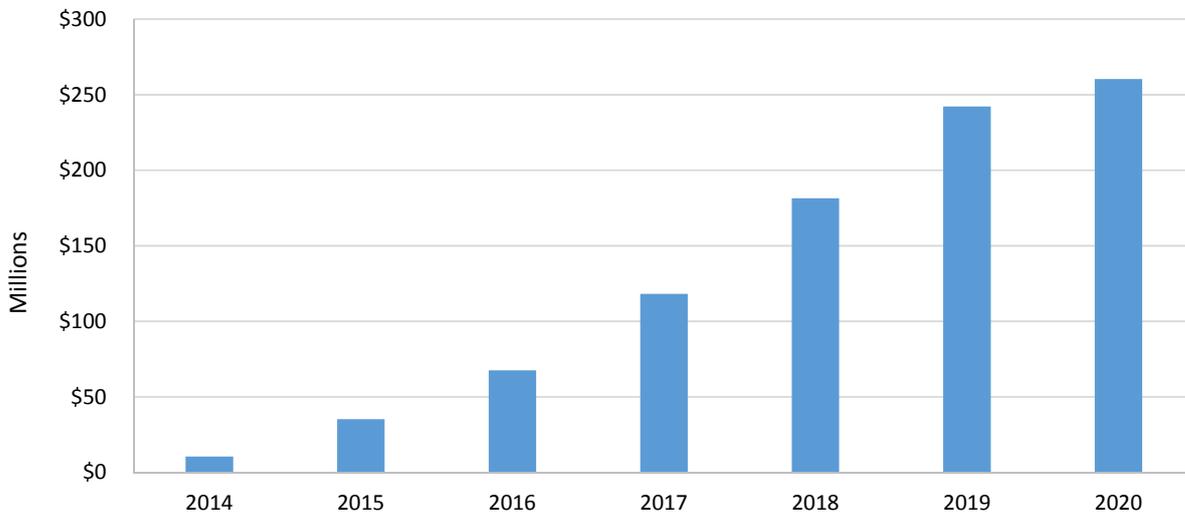


Figure 12. Global Market for Baby Monitors

That guilt motive suggests that the market will experience strong growth. Around 13 million babies are born to middle-class parents each year and by 2020 the estimate is that 10% of them will buy a Smart Wearable device for their child and in many cases multiple garments. By 2017, it will have exceeded \$100 million and be in excess of \$250 million in 2020. The market will probably find that more expensive garments, or at least their expensive sensor modules get reused by subsequent babies, so the hardware versus replacement garment percentage will change, limiting the growth in overall revenue.

This is a market which is susceptible to media scares. Stories that these devices have actually saved lives could double or triple sales. Equally, reports that a baby swallowed a battery or had been harmed by them could impact heavily on the market, or even bring in regulation which could slow it by several years. Yet properly addressed, it could be one of the easiest sales for smart clothing. There is also room for differentiation in data analysis. Although most parents will just use these as a monitor, the information being harvested could be used to compare your baby's development with others. That is explored further in the full version of the report. Regardless of that, these products, like hearables, may prove to be successful wearables in their own right without recourse to service models. Incidentally, researchers are already pre-empting baby monitors by working on ranges of smart maternity wear [54].

Child Trackers

What happens when your baby grows up? Within five years a significant number of new parents will have bought sleep suits for their babies and got into the habit of living with a connected child. That begs the question at what stage will they stop monitoring their children? The cohort of parents who have grown used to monitoring their babies is unlikely to want to lose that capability as their loved ones go to nursery and then on to school. Through the age of one to eight, parents will start to equip their children with tracker devices, which will almost certainly contain vital signs sensors. After the age of eight these may be discarded in favour of monitoring using mobile phones, so I've placed an upper age limit on child trackers in order to calculate the potential market size. The nine to teenager market may prove to be one of the better markets for smart watches (q.v.) and we are already seeing products like the hereO GPS watch which is due to ship around the same time as the Apple Watch [55], although the difficulty in monitoring children at this point will be in gaining their cooperation. From the age of eight onwards the child will have an increasing say in what they wear, hence they fall into the other categories that are covered in this report. One interesting trend from a number of companies is the integration of GPS trackers into shoes, as opposed to tags that fit on shoes. We have yet to see how they perform and whether they achieve a useable battery life, but it is an approach that builds on the success of Nike's footwear and has an established fashion brand play. A number of silicon start-ups are currently attempting to reduce the power consumption of a GPS receiver, with this as one of their prime market opportunities. If they succeed, it should push sales significantly. However, silicon is slow. It's probably at least four years before we see it in any products, and potentially longer.

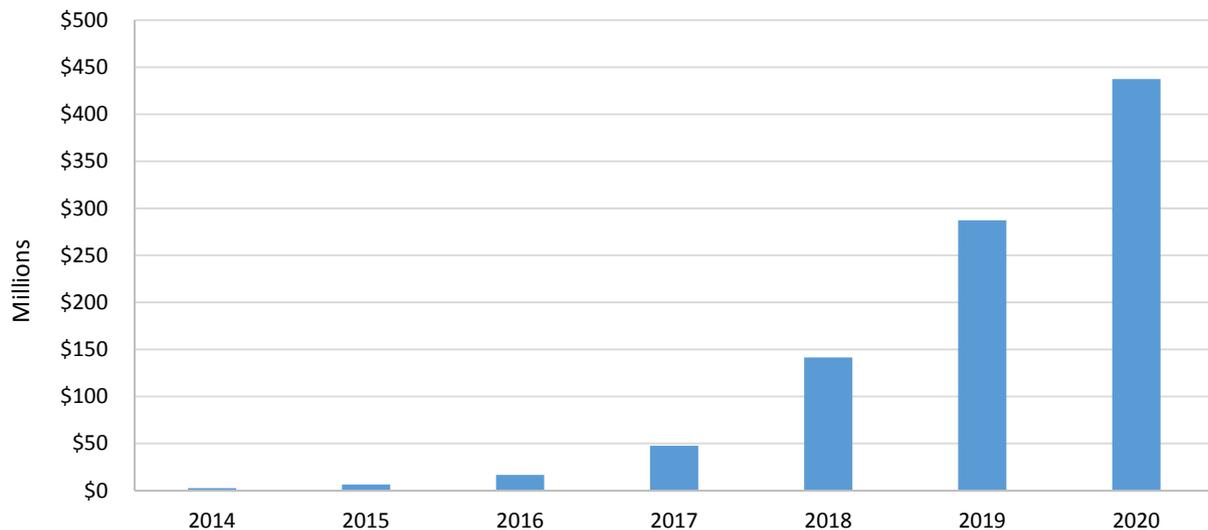


Figure 13. Global Market for Child trackers (age 1-8)

The market for trackers will be slower to take off than for baby monitors, as it will be fed by those parents who are moving on from monitored babies to monitored kids. Despite that, it should show strong growth from 2017 as parents accept that this is the next stage of managing their genetic contribution to the future of the human race. The uptake is also likely to be heavily influenced by school policies. As schools see that a significant proportion of their new intake are wearing tracking devices they are likely to succumb to pressure to make them mandatory for all pupils, not least because

they can then also be used for attendance reporting and meal payment.

Whereas baby monitors need not rely on a service model to achieve growth, location trackers involve the child being outside the home. That implies a cellular connection, which brings with it service provision. Hence almost all of these are likely to come with a service contract. In some cases that may be handled by the school which could also lease the wearable devices. If schools do start to use these to replace the current RFID tags which are creeping in to more and more of them, then the market potential is much higher. Trials of this technology are already taking place around the world, looking both at the cost benefit for the school and also the level of support from parents for what could be considered an intrusive level of monitoring. The acceptance of baby monitors could result in a groundswell of parental opinion that 24/7 monitoring of their children is now acceptable, accelerating the uptake within schools.

Take-up may vary according to national attitudes about child security. Any major media coverage of child abductions, such as a repeat of the Madeleine McCann case could vastly accelerate take-up. There are even opportunities for the more sensational sectors of the press to partake in the service model, offering child tracker subscription services whilst running lurid press stories of the risk to your children if they don't wear one.

Pets

Children are not our only loved assets. There are close to 200 million cats and dogs in the US. This year owners will spend around \$60 billion dollars on them [56], almost as much as the nation spends on beer. Of the \$60 billion, around half is spent on veterinary bills and a third on food, but that still leaves a significant amount for treats, particularly pet related treats for their owners.

A number of start-ups are targeting this discretionary spend, generally focussing on two areas – trackers for the animal, to find them if they are lost; or activity monitors to find out what they might have been doing. As well as GPS trackers, these include activity monitors to allow owners to assess the mood of their pet. The latter panders to the trend to humanise pets as members of the family, but anthropomorphising animals is a tried and trusted model in many markets from children's books to canine wedding ceremonies. The most amusing example I have seen for a smart wearable pet product is a patent for a cat collar containing movement sensors which detect when a cat is crouching and about to pounce on its prey. At that point a speaker in the collar emits a piercing shriek to alert the cat's intended dinner to its presence, allowing it to escape [57]. It seems an ideal project for the patent's inventors to turn into a Kickstarter campaign.

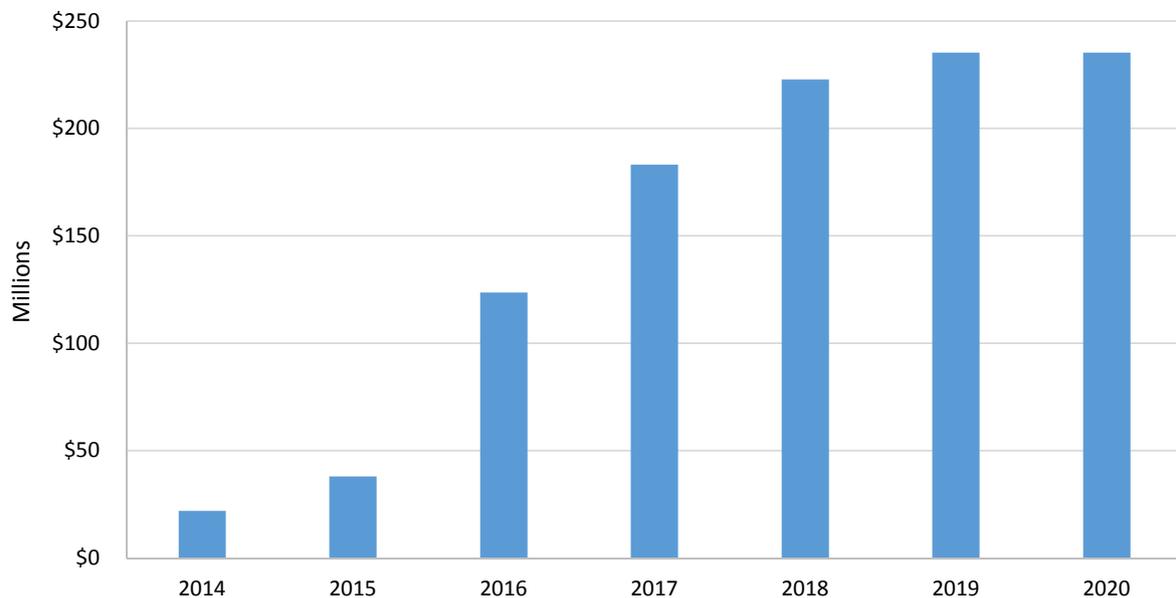


Figure 14. Global Market for Connected Pet Accessories

This market could grow surprisingly quickly, as knowledge of products which prove popular will spread virally through social media. This is one case where the fact that the Internet is dominated by cute cats will work to the market’s advantage. If the experience is good for the owner, then they will purchase devices for other pets they may have and give them as presents to friends who have pets. Again, the nature of the market where many owners have multiple pets will help accelerate growth. By 2017, owners may be spending more on Smart Wearables for their pets than they are on pet food, and by 2020 it will have increased the annual spending on pets by an additional 50%. That may seem a lot, but this is a market about buying unquestioning love, which has some very flexible spending limits.

Voyce [58], one of the products due out later this year is essentially a vital signs activity collar for dogs. It’s promoted as something that can “strengthen the bond as you and your dog learn, grow and socialise, letting you understand your dog like never before”. Others, like the TAGG pet tracker [59] have taken on board the power of fear in driving sales, quoting an ASPCA statistic that “every two seconds a pet is lost”. They use that to sell a service plan of \$9.95 a month for the first pet and \$4.95 for each additional one on top of a \$199 hardware sale. They’ve recently been acquired by Whistle. Whether that suggests success at this level or a lack of take-up or user commitment is not known.

Putting these segments together illustrates that pets and kids could easily reach a total market value of close to \$800 million by 2020.

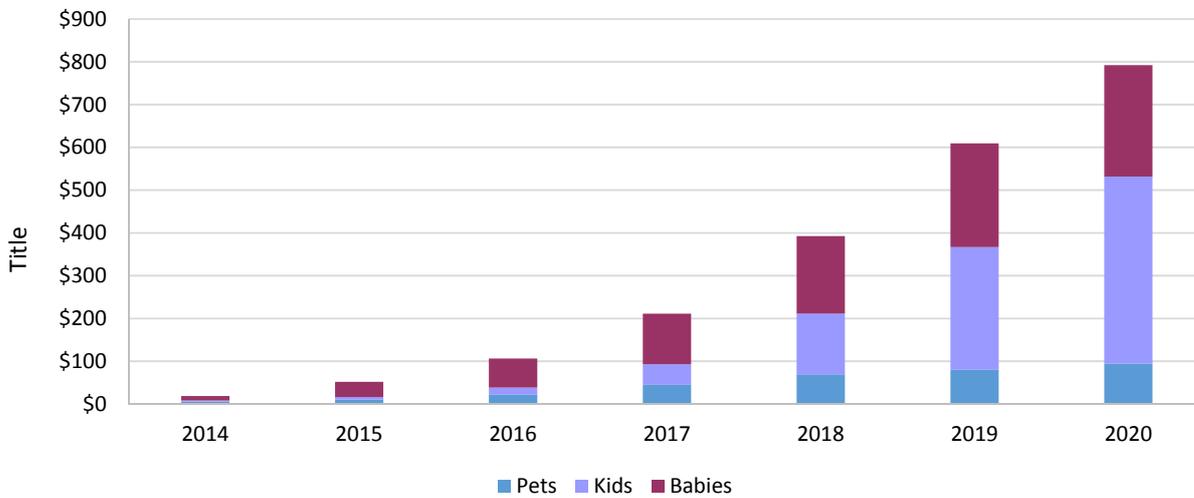


Figure 15. Global Smart Wearable Market for Pets and Kids

As pointed out above, the kids segment is very susceptible to media coverage and school support. It also excludes school mandates for children over the age of eight, when the parental drivers will subtly change. With the right societal climate this market could easily reach several billion dollars.

Both pets and kids are also ripe for service provision. The full version of this report looks at those opportunities, which could dwarf the hardware sales. It is an area of wearables which stands a good chance of making money for someone outside today's current value chain.

Fashion

Fashion, of which clothing is the major part, is the most challenging wearable for many. There have been plenty of cases of technology crossover – my daughter was buying garments from Cyberdog with embedded LED displays back in the late 1990s and we've had trainers with piezo-powered LEDs for even longer. For Smart Wearable fashion I'm excluding these and enforcing the principle that Smart Wearables must be connected. So we're looking at clothing like the Twitter dress [60], a connected fan shirt [61] or Bluetooth earrings [62], not at tiaras with flashing lights.

Smart clothing faces many technical challenges. It needs to be comfortable, it needs to be flexible, it needs to be washable and it needs to be chargeable. If any one of these features are missing it becomes a niche product for a catwalk model or a geek (rarely do you get to use both of those words in the same sentence). It's unlikely that we'll see these challenges met until around 2018, possibly longer, but when they are, assuming the resulting products prove attractive to consumers, the market could explode. However, clothing poses a problem for the consumer electronics industry. Unlike phones and tablets, all of the target audience have multiple items of clothing, not just a single, high-end, desirable one. It means this really is a multi-billion piece technology market. It's probably the only one that can match and then overtake the volumes of the mobile phone industry. But therein lays the problem. Selling multiple, everyday items is a very different proposition to the current approach of the consumer electronics industry.

When it does take off, it will be very different to today's consumer electronics' industry, not least because one size does not fit all. Whereas the average consumer has a choice of maybe a hundred different smartphones, tablets and laptops, a single market stall will provide them with a greater choice of clothing, each in a variety of different sizes.

In addition, clothing sells on individuality; outside group activities, people do not generally like to meet others wearing the same clothes as themselves. How a technology industry focused on limited choice will cope with that is unknown, but it will probably do it badly – how many of the people who happily buy the same model of iPhone would buy and wear a similarly limited range of iSkirts or iShirts? Smart Clothing needs a new manufacturing base and distribution channel if these products are to become an everyday consumer purchase.

There are indications that some parts of the fashion industry are beginning to appreciate and adapt to the problem. Made to measure is being slowly brought into the mainstream by automated measurement and cutting, while companies like True&Co are proclaiming the fact that they are basing designs for bras on measurements of over half a million women [63]. These techniques are still in their infancy. But sizing is a major challenge for smart clothing. It's a basic challenge even for current clothing which is echoed in the emergence and success of websites like Fitbay [64]. Depending on the sensors smart clothes contain, they will need to be a moderately good fit if the sensor is going to stay in contact with the body. That implies a degree of tailoring or made to measure which will keep prices high for the foreseeable future.

At some point, made-to-measure will descend to a price point which brings it to volume. Even so, it may play more to online purchases, rather than the instant gratification of the retail store. That distinction may be important in the development of the smart clothing market. High streets and department stores are popular because shoppers like the diversity of choice and the social aspect of buying clothes. Wearable may have a practical problem in emulating that. Retailers have yet to work out what a wearables changing room will look like. It's a small challenge, but indicative of the changes that will need to occur if the market is to succeed.

Nobody knows what will catch the public's imagination for smart clothing. Initial interest has seen a number of concepts:

- Clothing which is internet connected, which is essentially a wearable display
- Clothing which uses sensors to provide social interaction, such as changing the colour of the clothing to express your mood or location, and
- Haptic clothing which can share physical sensations

Each has a long way to go before we get to a mass market in smart clothing. One step in that direction may be the development of what I will term Social Clothing. This falls into the last of the categories of connected clothing listed above, which lets you share physical feelings with someone else.

Social Clothing

For the last ten years, London based Cute Circuits has been at the forefront of innovation in smart clothing. They're perhaps best known for their Twitter dress [60], but invented what may be a more important concept back in 2006 with their Hug Shirt [65]. The Hug Shirt contains sensors that measure the strength of touch, skin temperature and heartbeat along with actuators which can recreate them. The Hug Shirts communicated via Bluetooth and mobile phones (back in 2006 they relied on text messages to send information) so that two people wearing Hug Shirts could experience the other's physical movements, allowing them to send each other hugs.

The Hug Shirt was essentially a pair of products for two people to share feelings. Wearable Experiments [66] took the concept one stage further, developing their Alert Shirt which lets you feel how football players' bodies are reacting as they play. They made a limited edition of 2,100 shirts which were sold as part of an Australian Football TV subscription by Foxtel. Each one allowed a viewer who was wearing one of them to experience the movement of one of the key players during a live match. User feedback is positive, though not universally ecstatic, acknowledging that this is the beginning of a trip. (Wearable Experiments also make the Navigate Jacket and Fundawear for Durex – two other products which illustrate the wide potential of haptic clothing.)

If the concept of social clothing can be developed successfully it could dwarf the activity clothing market. It is an interesting prospect for major sports clubs to consider, not least because of the size of their supporter fan bases which could be captive markets. Each time a goal is scored every fan wearing one of their smart shirts would feel the embraces of the other team members. If a company can come up with a convincing après-goal hug-shirt they could probably sell millions of them in the run-up to the next World Cup.

I don't consider this to be part of the sports and fitness market, as those wearing them are likely to be watching at home, in the stadium or in the pub. It is a piece of spectator clothing for fans who want to experience those at the top of their sport. The shirt is not measuring the person wearing it, it's acting as the sink for streamed content, rather than just watching them. If more of these come to market, future generations of fans will not just remember "being there", but physically experience scoring.

In this case the content is the physical movement of a player. It heralds the next phase of content provision. After music and video the next opportunity for content is sensation. Manufacturers and service providers need to latch onto the opportunity of selling a more immersive experience for spectators. It's not dissimilar to what we're seeing with Twitch [67] in gaming, where each month some 45 million people are vicariously watching experts playing games rather than playing themselves. Along with sports followers, there is a massive audience who want to absorb an experience as passive participants. The more that experience can be enhanced, the more they will feel part of it.

That extension of social belonging could extend to other community and group activities. I don't know what the appropriate connected wearables are for Zumba classes, but there is almost certainly an opportunity there – as there is with any market that understands the value of franchised physical activity. Smart Clothing allows a new bond to be formed in any sort of group. These opportunities may well drive the technology, as they can take advantage of existing service models such as season tickets, premium TV subscriptions and club membership. If they prove successful it also normalises the

experience of smart clothing, making it easier to enter our daily lives.

Smart clothing offers the opportunity to sell multiple items to a consumer, but how long will people wear wearables? The social clothing examples are event specific; once we move to smart everyday clothing it becomes the same question as asking how long do you wear your clothes. Today that depends on mood, activity, fashion and state of cleanliness (so the answer may be gender specific). With Smart Wearables the smart element must remain interesting, either in an autonomous way, or because the presentation of information – in this case in the form of sensation, remains compelling. That remains the biggest challenge for this industry.

Smart Jewellery

A final element of the smart clothing market is smart jewellery. Some of this will be a part of activity trackers, some of it ear worn products within hearables, but there are a number of companies designing products which will be purchased first and foremost because they are body jewellery. At CES last year, Cambridge Silicon Radio, one of the major suppliers of Bluetooth chips, demonstrated a number of smart jewellery concepts [68]. A slew of smart jewellery companies had products or prototypes on display at CES 2015. This is unlikely to be a vast market, but with a high price tag on products it could reach sales of over \$50 million by 2020.

It also encompasses a level of accessory products. Misfit's Shine – one of the most elegant activity trackers, is an interesting example here. When Misfit ran their Indiegogo campaign [69] they discovered that users were as interested in how it could be worn as in the product itself. As a result Misfit has provided a range of holders, including necklaces. Accessories like this could end up providing a significant chunk of profits for smart wearable companies and should not be lightly dismissed. Kovert Designs [70] has had a similar experience. They listened to customer feedback for their jewellery, which said that they should remove all of the extraneous technology which was only there because it could be. Instead, customers preferred that they kept the products beautiful by keeping them simple. It's an important lesson for an industry that is often blinded by the diversity of sensor opportunity – less can mean more.

As mentioned in the introduction, companies like Swarovski [4] could not only wrest the market from the consumer electronics industry, they also have the capability to define its direction. I am struck by the fact that almost every fitness tracker manufacturer appears to think that numbers and charts are compelling to the bulk of the population. We are not numbers and it may be that companies that have never treated us as such have an inbuilt advantage in competing in wearables. Their lack of obsession with turning us into fitness and health accountants may ultimately prove to be the winning approach to more compelling products. There is a misunderstanding that wearable tech needs to come from technology companies. They've led the way because they of their electronics manufacturing capabilities and their need to make the market happen, but that doesn't mean they will succeed. Successful fashion brands like Swarovski have plenty of funds to buy in any tech that they need. So once they recognise the existence of a market and formulate an ability to own it, they could become formidable competitors in their own right. Going back to their video [5] there is a defining moment thirty seconds in when you notice the woman is wearing three bracelets and you realise you're seeing something which no other wristband company would ever dare to show. With Swarovski it looks great.

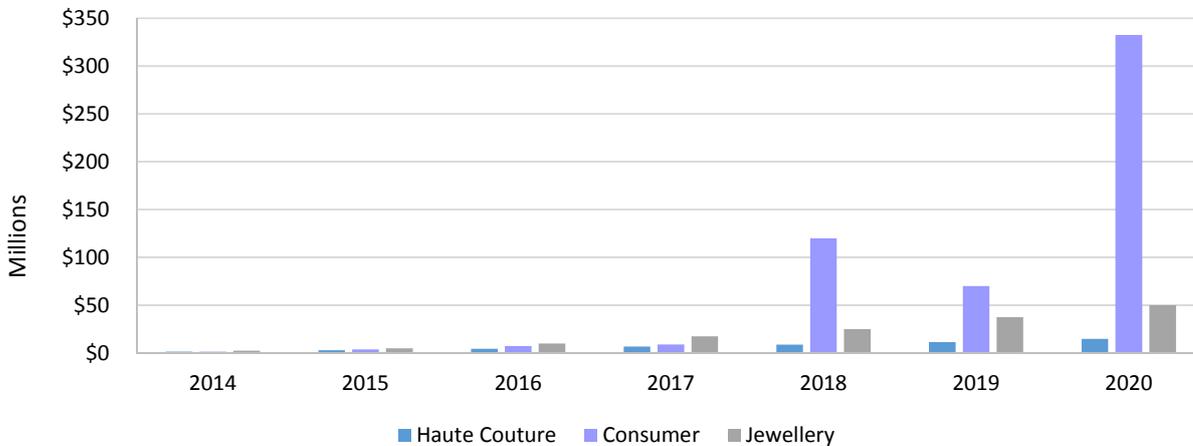


Figure 16. Global Market for Smart Clothing

Most smart clothing sold today is still designed for the catwalk, stage or celebrity functions and carries a high price tag. It's often designed for specific events, so sidesteps the everyday cleaning and battery issues of most wearables. For the next few years that will remain the case, although we will see the first few items under \$200 begin to reach the consumer. The tipping point will be 2018, where social clothing in the form of fan wear could see a massive increase with the next World Cup. 2019 is likely to see a fall in sales as companies use the experience of the World Cup sales to refine their smart products for the 2020 Olympics. Depending on the success and fan uptake these figures could exceed tens of billions of dollars of revenue if they become the must-have accessory for sports fans. It is quite possible that these will not be hardware sales, but subscription sales, in which case revenues could reach almost \$100 billion in 2020. The technical development that this revenue stimulates should also drive a mass market in smart clothing after 2020. The potential revenue streams are explored in more detail in the full report [6].

Smart Glass and Augmented Reality

First a disclaimer – I'm not going to include Virtual Reality helmets in this analysis, as they're such an extreme case of wearable technology. There is certainly a considerable level of interest in them, but they fall into an almost unique silo amongst Smart Wearables of being totally anti-social. Whilst you could argue the same applies to headsets, they are at least worn outside the home and the choice of brand reflects and signals the wearer's personality, as do the bulk of things we buy and wear. VR largely does the opposite, removing those who wear them from social interaction. This is also partly an admission that I have no idea where this market will go. People will pay inordinate sums for VR, the equipment which powers it and the resulting opportunity to escape from their everyday world. So do those who believe in its future as shown by the \$2 billion paid for Oculus [71] by Facebook and Rothernberg Venture's establishment of a virtual reality incubator [72]. There is money to be made and an eager audience – Oculus has taken orders from over 75,000 developers for their Rift, but it is interesting that they are adamant that they are still selling a development system, not a consumer product. However, Mark Zuckerberg is confident that by 2020 they will have sold between 50 million and 100 million Rifts [73]. If that's the case it implies an annual market approaching \$10 billion in 2020, and that's just for the hardware. The cardboard fold-up VR goggles [74] that Google gave attendees at

the Google I/O conference in 2014 recognise the same pent-up demand, albeit at a rather different level of immersion. As mentioned above it is interesting to see the growth in Twitch [67] – a web broadcasting service which lets gamers watch experts play games. Many pay a subscription and would probably pay more for a VR headset to augment the experience. Twitch were recently acquired by Amazon for around \$1 billion after a bidding war from several potential acquirers. That may give them extra resources to fund wearables, but virtual reality remains a very separate silo.

A similar silo I'm skipping over is connected sex toys. Currently, in terms of devices shipped, they are almost certainly outselling augmented reality headsets and smart glasses and possibly even smart watches. However, I doubt we'll see Facebook or Google acquiring companies like Vibease [75] in the near future, however much they see the value of the data they would collect from them. It's interesting to see that Vibease has already latched onto the value of a sensation content stream for their devices. Meanwhile OhMiBod [76] used CES to preview a new range of sex toys with heart rate and other sensors. Whilst companies like these may never be acquisition targets for well-known brand names, our desire for personal pleasure has consistently driven the development of technology, whether that was printing, photography, film or the Internet. The companies in this area will probably be equally effective in wearables and the provision of sensation as content, whatever the more prurient end of public opinion may think of them.

Public opinion in another form brings us to Google Glass - the most socially contentious, high profile wearable product. Google Glass was always promoted as an experiment to see what people would do with the device – it was not a consumer product. That hasn't stopped the media treating it as one, nor numerous manufacturers starting work on competing smart glasses. It was interesting to see how quickly the media chatter changed to disdain when Google announced the closure of their Glass program just after CES 2015. I personally think that reaction was misjudged. Google learnt from the experiment and understood that the short and medium term opportunity lay in Glass' professional applications, not in consumer ones. Putting Tony Fadell (their \$3.2 billion protégée [77]) in charge of the program [78] indicates how important they think the future potential could be.

The cleverest aspect of Google Glass is a very basic one. Its designers understood that the best way of getting data into the human body is through the eyes and of getting it back out is by voice. Once you've realised that, much of the form and function of Google Glass follows automatically to support those principles. But as the Glass experiment ran its course it illustrated that the obvious may not always attune with society's current norms. The fact that Glass contains a camera as one of its sensors is breaking a barrier between what an individual sees and then decides to report to their peers and what can be automatically broadcast without thought or consent. It changes the trust relationship between personal, social and public.

The world has come to love smartphones because they're a computer in our pocket which we can take out and use when we need it. Smart watches offer the prospect of accessing the phone's more common functions without taking the phone out of our pocket, simply by touching our wrist. They're not particularly obtrusive. In fact the most popular ones try hard to disguise themselves as watches. Smart eyewear takes the experience one stage further, gathering and giving us information anywhere and everywhere, overlaying it on everything we see. To many, that feels like a step too far; taking over their lives and intruding into the privacy of others. But privacy is not the only concern. Wearing a

visible product to enhance our senses has some other interesting connotations. Products, like glasses and hearing aids have progressed a long way from the point where they were often seen as a badge of disability. It's taken a lot of marketing and designer badging to effect that change in perception. What we put on our face and head says a lot about us. Promoting a fashion trend can take a lot of time and money. Manufacturers of smart glasses need to be aware that wearing them brands the user, but not only in a marketing sense. The technical challenges in designing smart glasses will probably be minimal compared to the social ones.

What the Glass advocates are predicting is that people with no vision impairments will want to start wearing glasses because they're cool. Even John Lennon and his iconic glasses failed to achieve that beyond a few extreme devotees who took to wearing plain glass lenses. Managing that change across society is going to require a massive perceived benefit for users, which is far from obvious.

I have prosopagnosia – I can't recognise faces, which is a major embarrassment when I meet people. Face recognition glasses will probably be able to solve that. Despite the fact I wear glasses today I'm not sure I'd want to make that move. Something still tells me that my world is my world, not my computer's. That may change in time, but I think many people feel the same.

This is the challenge that faces any form of smart eyewear in the consumer space. There are many business uses where they may succeed – almost anything where something needs to be recorded or a user guided and the resulting efficiency provides a cost saving, justifying and normalising their use. But once we leave work there is a massive barrier of social acceptance for them to climb. At CES in 2015 it was obvious that many companies had not taken this on board, but were blindly following Google's lead. Two weeks later, they must be wondering what Google's announcement means for this market? I'm fairly confident that the Google experiment will not only continue in a new professional guise, but that it will accelerate with far more of the next generation of Google Glass selling in the second half of 2015. However, they won't sell to consumers, so they will fall out of the remit of this report. On the other hand, seeing them succeed in professional and industrial use may be the thing that makes them more acceptable to a consumer, particularly if they include high-profile applications. The experiment continues.

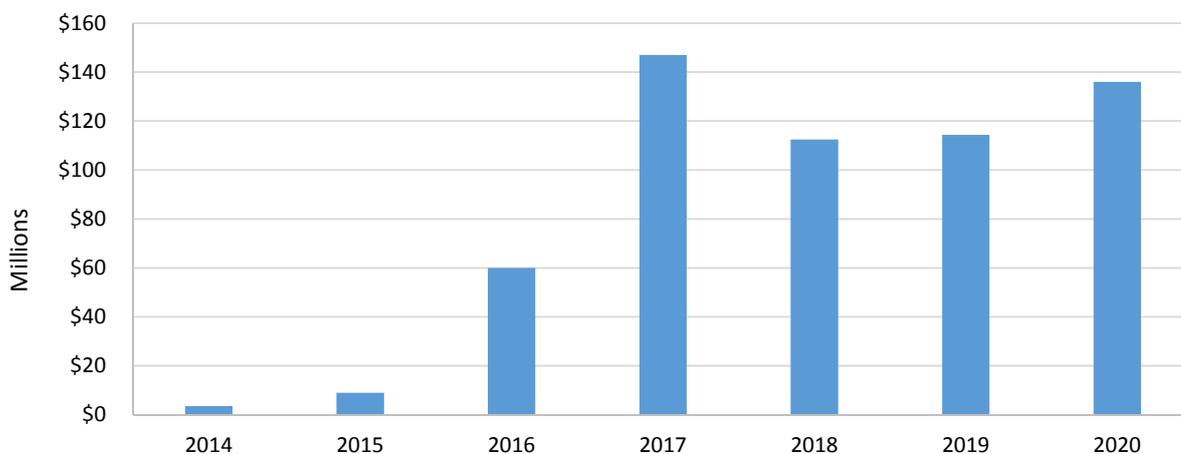


Figure 17. Global Market for Smart Glasses

As a result I see a very constrained growth for smart glasses in the consumer sector. I am aware these numbers are massively at odds with other projections. IHS believes that in 2016 shipments to consumers could reach 6.6 million units [79], whereas I believe they will struggle to reach half a million. Many of the more aggressive numbers feel like a technology push which ignores social acceptability. Instead I expect to see moderate growth as a number of manufacturers probe the market by releasing relatively small batches of products to consumers in the hope that Google was wrong. These will generate an initial backlash which is likely to be felt around 2018, where growth will slow and prices will fall. After that the market may start to take off, largely depending on how the new Google experiment plays out. Even then it will probably vary significantly from country to country as different cultures adapt differently to being always recorded.

At some point the social barriers may relax. The timing for that is almost impossible to predict. Smart glasses suffer from being “in your face”, both physically and metaphorically, which means they are the most provocative incarnation of automated observation. Intriguingly, the battle for constant social recording may initially be fought in another sector of wearables – smart cameras.

Smart Cameras

Smart Cameras are a rather neglected item which have slipped under the radar of many analysts. Originally conceived as sports cameras, they’re being introduced into the general consumer market as a means of recording your life. Products like those from GoPro [80] started the trend for wearable cameras, although these are largely helmet mounted video cameras. Recon Instruments [81] have moved a lot further with sports goggles with head up displays, bridging to the virtual reality world. But the most interesting product in terms of redefining the market is the Autographer [82].

Autographer is a wearable camera that doesn’t look much like a camera. The clever innovation is to incorporate an array of sensors and algorithms that try to anticipate what you are doing and when it would be a good time to take a picture. As well as appealing to sports users Autographer are promoting their smart camera for holidays, festivals and everyday family life. Essentially it allows you to record your best memories without the hassle of having to experience them through a viewfinder. The Narrative Clip [83] is similar, but less smart, taking pictures at a preset 30 second interval, or when you tap it. Both are a very interesting concept. Because they’re not blatant “headware” they become socially much less intrusive. Products like these may prove to be the Trojan Horses which make ubiquitous recording more socially acceptable. However, a challenge that all of them have to solve is what to do with the myriad of images these devices capture? They take around 1,000 images every day. It won’t take long for most people to find the task of sorting that quantity arduous rather than compelling. Unless that is solved, users will quickly find the effort outweighs the emotional benefit of capturing the moment, consigning the camera to the rear of a drawer. This area is attracting new companies like Cognivue [84] who are developing techniques for cognitive image processing, which may help.

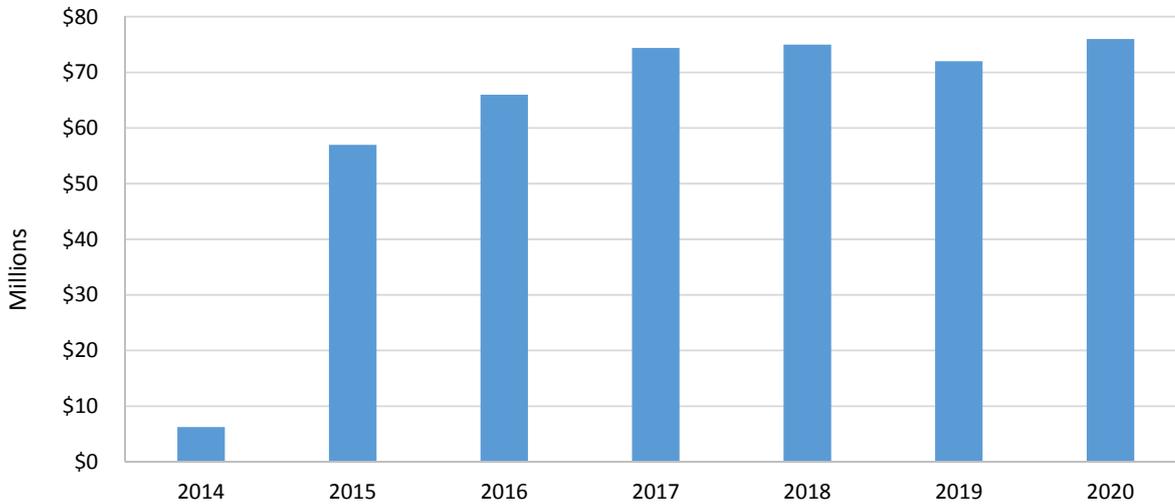


Figure 18. Global Market for Smart Cameras

Volumes of smart cameras will grow steadily from 2015, but the price is likely to fall dramatically, keeping the overall market revenue flat. This is a segment which needs to find a service model, otherwise it may be subsumed as the functionality becomes embedded in cameras from traditional suppliers. Today it is an area of innovation, but that window may not remain open for long.

Gesture Recognition

Gesture recognition may prove to be one of the unexpected hits in wearables. It's generally the poor relation of augmented reality, but it has immediate uses in many daily area of life. The most prominent product is Thalmic Labs' Myo armband [85]. Today it's a bit of a geeky novelty, but, as their video illustrates, it can have a multitude of uses, many of which are fun. Some aspects of gesture recognition will appear elsewhere, particularly in clothing, and these markets may merge, but it is worth considering it as a segment of Smart Wearables in its own right.

Gesture recognition is spawning new sensor designs and start-ups. Companies like Chirp Microsystems [86], which has spun out from UC Berkeley, is an example of new thinking which is going into this area. Another interesting entrant is Nod with their gesture ring [87]. It's currently clunky, but it feels that it might be only a few generations away from morphing into a piece of desirable smart jewellery. In the hearable space, Elbee are also using gesture as a prime selling point of their earbuds. Expect gesture to become more prominent as the market evolves.

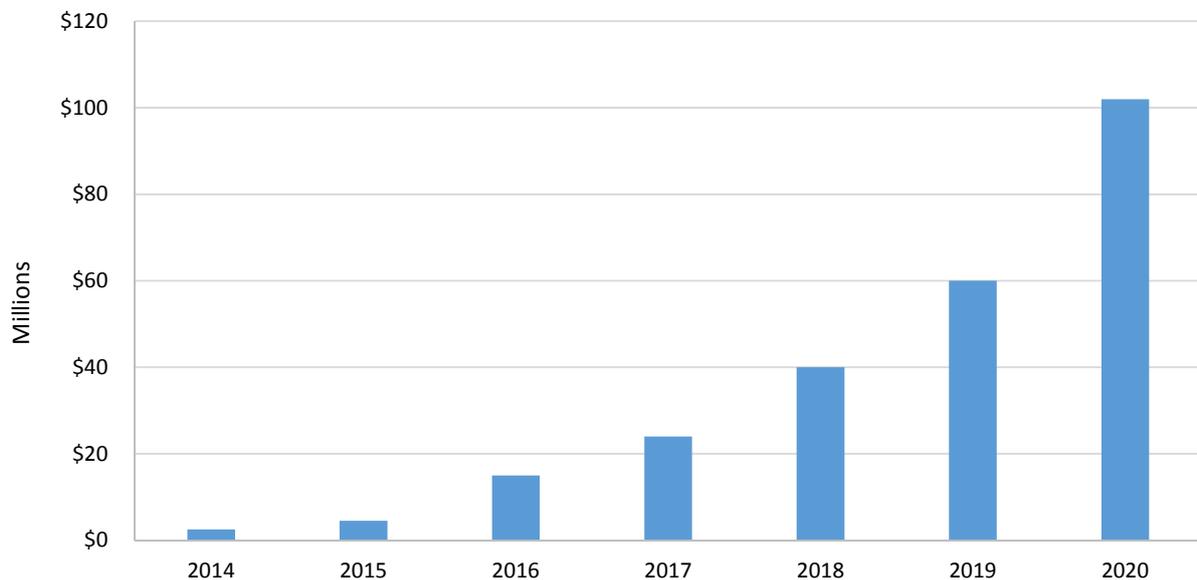


Figure 19. Global Market for Gesture Recognition

Gesture control armbands, gloves and rings will see a steady rise in sales. Unlike most other Smart Wearables, which will connect to a smartphone or tablet, many gesture control devices will interact with other products, from drones to TVs to toys. The need for two ends of a solution from different manufacturers and the challenges of interoperability will moderate their growth in the early years, but it will have breached \$100 million by 2020. Although little recognised, gesture control products could outsell smart glasses over the next six years.

Smart Watches

When I wrote the first draft of this report I was sceptical about the smart watch market. That was several months before the Apple Watch announcement. That announcement was one of the most anticipated in recent years, generating massive amounts of hype, both within the industry and amongst industry commentators.

The prospect of Apple owning the wrist galvanised many other manufacturers into pre-empting them, of which the most notable contenders were Pebble, Motorola, Asus, LG and Samsung. The latter not only started shipping their Android-based Gear, but even rushed out their second generation Gear 2 and third generation Tizen-based Gear S prior to the Apple event. Asus' ZenWatch and Motorola's Moto 360 have the advantage of looking more like a real watch, but that's not necessarily the point if you're trying to create a new market. Many in the industry want to believe in these products. Deloitte, just one of the prophets in the smart watch priesthood claim Android wearables (watches, glasses and wristbands) will ship 2 million units in 2014 with an overall value of \$200 million [88]. Canalsy put the wider smart watch market higher at 5 million units [89], and NextMarket Insights even higher at 15 million, growing to 373 million smart watches in 2020 [90].

These pale into insignificance before the true acolytes worshipping exclusively at the Apple altar. Morgan Stanley predicted sales of 30 – 60 million for an Apple Watch in its first 12 months, rising to a cumulative 250 million after 3 years [91]. Not to be outdone, CIMB Securities reckoned it could be 65 million for year one [92]. Kantor waited until after the launch to ask iPhone users whether they'd buy one and told the world that around 40 – 60% of them did, which would see Apple shipping around 37 million watches in that first year [93], although with the sales success of the iPhone6 that could mean anything up to 100 million watches. In contrast, a year before it was unveiled, Apple Insider, who should know the community better than most, conducted a similar poll and found “as many as 4%” of iPhone users would be early adopters, translating that finding into an estimate of sales between 5 and 10 million units in the first twelve months [94]. I am aware that these numbers don't necessarily add up in terms of percentages and total volumes, but that's overexcited analysts for you.

When the announcement came, it only generated a muted whimper of excitement. It wasn't what most commentators had expected. That was hardly surprising given the level of hysteria which had been whipped up prior to its unveiling. Whilst a lot of subsequent reviews have complained about its lack of functionality I found that I warmed to it, or at least its potential. It's not just clever packaging of technology, which is what exemplifies the Asus, Motorola, LG and Samsung watches – it's a redefinition of the purpose of the wrist. I think it may be more of a game-changer than has been reported, but not necessarily in a positive way for much of the smart watch industry. Before exploring that, let's look at the remainder of the smart watch market.

One thing the Apple announcement is likely to have done is to decimate the market for competing smart watches in 2014. Showing their creation off just before the Christmas period, but not shipping until Easter 2015 (which may well slip) will have left many of their competitors facing Christmas feeling a bit like the turkeys that will grace the dining tables – they've been well and truly stuffed. Many would-be purchasers are likely to have waited for the Apple Watch, which will leave distributors desperate to offload stock of everything else before the next new model arrives. For many manufacturers, that next model is already on the brink of production, giving them the problem of delaying or killing it, or building up an inventory which may end up being given away as a free accessory for a phone. Even worse, the Apple Watch won't be available in time for them to analyse it before they embark on their next product design cycle. They've effectively had the carpet taken out from under their feet (or wrists) for the next eighteen months, leaving them out of the running until Christmas 2016.

Despite that, and with reservations about the desirability of these products, I would not be surprised to see the Canalis figure of 5 million smart watches in 2014 was exceeded, as there was a lot of stock coming into the channel. In 2013 around 400,000 Pebbles were sold and there is an eager audience for something new, despite the Sword of Cupertino hanging over the manufacturers' heads. The Moto 360 and ZenWatch are well-styled. On that basis alone they probably found their way into several million Christmas stockings. I also noticed that all of those models were being sold in the luxury tech shops in Tokyo, Taiwan and Hong Kong before Christmas. But will the sales continue after the Apple Watch arrives?

The basic problem with all of these smart watches is they only do the things that your smartphone already does. They don't provide users with any new applications. Given the fact one needs a smartphone to make the smart watch work in the first place, it's difficult to see why many will find it

compelling. There will naturally be people who buy one for the novelty value and because it's new. But that's just a fad. Fads only turn into a market when the product impresses the wearer's friends enough for them to buy one and everyone then starts replacing them with newer models to stay ahead and access the extra functionality. Buying one and putting it in a drawer after the first few months doesn't count. The back of the drawer is not a compelling product destination for growth.

ON World is another analyst aiming high. They believe that by the end of 2018, over 300 million smart watches will have been sold [95]. I'd suggest it will be less than a quarter of that number. That chimes with ABI Research's senior practice director Nick Spencer, who recently observed that "End users have been happy to ditch their watches and use smartphones to tell the time, so extending smartphone functions to the watch is a weak use case and retrograde step" [30]. Even Pebble had their doubts, as shown in a refreshingly honest analysis of the market by Myriam Joire – their chief evangelist [96] at last year's Wearable Tech Expo. Sadly, she was fired shortly afterwards [97], suggesting that in an over-hyped industry honesty may not always be the most admired quality.

The problem for smart watches was that they are trying to reverse a longstanding trend of not wearing watches. My ad-hoc research suggests that in London watch wearing has fallen below 20% for the target demographic. But manufacturers of smart watches have another problem. These are devices which impose an additional task of charging and it is questionable what the return is for users? Unless the equation can move from merely new and useful to exciting, the smart watch market will struggle.

Another issue is their size. Myriam Joire's view is that the only two which look like watches are the Pebble and the Moto 360 (albeit she hadn't seen the Asus ZenWatch when she made that observation). I'd concur with that. Almost all smart watches seem to be designed for West Coast consumers. Specifically people who only ever wear T-shirts, because the majority of smart watches are too big to fit under the cuff of a long-sleeved shirt. It means that for most people, these are accessories to your clothes, not the other way around. Manufacturers need to take that on-board. If you look at conventional watch sales, only a tiny minority are bought for show. Yet with the exception of the Pebble, every smart watch is trying to be a statement product. Currently the constraint of battery size makes that a difficult problem to solve. Which is a sales barrier for anyone living in cooler climates, or who's not male. I've yet to see a mainstream smart watch designed for the female wrist.

Not everyone seems to be bothered by size. It amazes me that the Neptune Pine phone [98] sells, as it's the sort of wearable tech that looks like a throwback to 1960's Sci-Fi movies. They do acknowledge that by positioning it as "an experiment in mobile computing". I just wonder how many will want to be part of that experiment.

However, none of this has diminished the industry's enthusiasm for seizing the wrist, in what might be described as a case of *carpus diem*. Intel's acquisition of Basis for an alleged \$100 million [99] indicates that there is a belief that this will be a major market. Unless their marketing department is just spending money for the opportunity to launch an "Intel Outside" campaign.

Which brings me to the difficult task of predicting the market. I had thought it would split into two distinct segments. The first would be expensive watches – ones which believe they can play in the "haute horologie" market of Rolex and Breitling, or at least aspire to. Samsung, Acer, Motorola et al fit there. The second was cheap watches that are little more than wrist worn ringtones. The Apple

Watch has made me think again. I now believe it will form its own category, which it will dominate for at least the next five years until it is either forced to let others join the game, or disappears because consumers aren't interested. The reason is a subtle but important one. Until the Apple launch everybody believed that a smart watch complemented a smartphone. What Apple demonstrated, and was castigated for by many who didn't appreciate the difference, is that they've turned the tables. In their case, *the iPhone complements the Apple Watch*. It's a very neat trick, for which they deserve credit.

Few appear to have appreciated this turn-around. We've heard complaints that the Apple Watch doesn't contain GPS, so you don't know where you are unless you have the phone. Others believe that it will only succeed if it evolves to become a 4G digital hub. These and similar negative technical gripes miss the point, which is that it is genuinely a product in its own right. It can interact with other Apple watches. That may be twee at the moment, but it has the potential for innovative apps that have nothing to do with phones. It can pay for things, which we'll come back to. It also makes extremely clever use of wireless technology, which should help its battery life [100]. Here, as elsewhere, Apple has been thinking very differently from most of the rest of the industry.

In a very readable article, written from the viewpoint of a watch collector, Benjamin Clymer observes that "If you wear an Apple Watch without your phone, what can it do? If it's only a watch it has a problem." He goes on to admit that "in its own way, Apple really pays great homage to traditional watch making. It is still not as cool as a mechanical watch, to real people. I don't see people that love beautiful things wearing this with any great regularity. It is ultimately a Market Leader in a Category No One Really Asked For" [101].

That is a profound point and the beauty of Apple's concept. They have generated a category that no one asked for - it's not the smart watch that anyone expected. But it acknowledges that the traditional view of a smart watch may have been an invalid category. Apple's task is now to persuade the world that it is a product which they want to wear.

That gives us three categories to consider for smart watches. The cheap one is fairly obvious – it's a wristband with a clock and remote notifications from your smartphone. Bluetooth Smart chip vendors are already pushing reference designs into Far Eastern manufacturers and the only direction these products will go is up in volume and down in price. By 2018 the average price for these will have fallen below \$20, with over 60 million of them being sold. How they will differ from fitness wristbands is debatable. At this level the two markets will converge, each shipping a similar number of devices. The key differentiators will be the size and quality of the display and strap, which will place the watch at a slightly higher price point, as people still seem to want a smart watch to look like a watch, while they tolerate fitness bands looking like a piece of plastic. The Withings' Activité [102] seems to be the only exception to the rule that fitness doesn't look good. And the channel to market will probably be different. At the lowest price point, a fair percentage of low cost smart watches may be bundled with handsets.

The branded / expensive (non-Apple) segment will have a hard time. If my guess about the superior user experience of the Apple Watch is correct, competitors may be frozen out of the market for at least two years before they have a chance to catch up. That will lead to a lot of remaindered products left in warehouses, which will put pressure on price. The most likely effect will be for the price to plummet

from the current \$300 mark to an average price below \$90 by 2018, as the only way to tempt customers away from the Apple Watch user experience will be by seriously undercutting the price. Without some user interface innovations, which don't show much sign of existing, it's difficult to see how manufacturers will pull themselves back out of this situation. I do see volume growth, but largely because these products will be a cheap alternative to the Apple Watch – typically at around a third of its price. Because of that they will outsell it, but only just.

Apple, whether through chance or design have managed to give themselves a clear run at the market opportunity with a product that may well keep its premium \$349 price point for the next five or six years. However, they have challenges which could still trip them up. The first is to ensure that the watch does enough to justify its price. Many of those who own an iPhone have never experienced its full price – they were bought with a mobile contract – an iPhone6 can already be bought on contract for under \$100. We don't yet know how the Apple Watch will be sold, but as it won't generate more revenue for operators it probably won't be subsidised. That's where the different survey results from Apple Insider and Kantor come into play – will it be 5% of users or 60% who stump up to buy it? Although the design is beautiful, it is probably still considered too large by many, further limiting its sales. Moreover, where an iPhone may be passed down the family with each upgrade, I'm not sure we'll see the same effect with watches. They're likely to have a significantly longer life cycle – possibly up to three years and a significantly lower resale value. One month after Christmas, the average resale value of branded smart watches like the Moto 360 on eBay is around 40% of the original retail price.

That rapid devaluation should be telling smart watch manufacturers that they are not competing in the same market as the prestige watches they're trying to replace. Designer watches are not just built for life – the expectation is that you'll pass them down to the next generation. You certainly do not sell them on within 30 days. If the new smart watch industry tries too hard to copy this market they may find they fall foul of some very different user expectations to the ones with which they are familiar, which result in them designing the wrong product.

There's another important difference. Throughout those lifetimes of being a family heirloom you don't need to wind a top end watch. That's a sharp contrast to smart watches which may need charging daily. We don't yet know how long the Apple Watch will run between charges – current estimates suggest it may be less than a day, but having yet another device to charge will not enamour users to them. It's only one of the technical challenges ahead and affects every manufacturer.

Battery life and charging may prove to be the most important differentiator in the smart watch market. Despite the development and marketing muscle of the consumer giants, the most consistently sold and worn smart watch appears to be the Pebble. Its main differentiator is the e-Ink display, which gives a battery life of at least a couple of months. Some might argue that it's not the most compelling display, but then, neither are the displays of most conventional watches. I'd suggest that the industry could learn a lot by looking at how long users wear their watches and how often they charge them. If they're bright, this is the piece of information they should be pulling back from every watch they sell – attempting to gauge how long it is before it's consigned to the back of the drawer. My guess is that few are doing that. It's one of the most important pieces of data for every smart wearables company to acquire to help them understand what users really think of their products – which ones they stick with and which they don't. The fact that few do shows how far they are still removed from being data

centric companies.

Sony's recent *"highly successful"* crowd-funding campaign for its e-ink FES watch [3] may have indicated that battery life is important to consumers. Once the media discovered that the watch was from Sony's research department they waxed lyrical about its popularity and long battery life and the resulting success of the crowd-funding approach, despite the fact that only 137 people had signed up to buy one. I'm not sure what it really says about market appetite for longer battery life, but the extent of coverage that was generated from the commitment of fewer than 150 buyers says an awful lot about how overhyped the market is.

There is a further point to make. Whereas the Pebble – the first successful smart watch, was designed to work with any smartphone which had Bluetooth low energy, the Apple Watch will only work with an iPhone. More specifically a recent iPhone. Other manufacturers are also working to provide maximum functionality only when the watch is used with their phone. As smartphones become more homogeneous the smart watch allows the phone to stay hidden in your pocket or bag, taking up the role of the conspicuous brand. Taking the view that the phone complements the watch reinforces this change. It's a double edged strategy which acknowledges that the form factor of a smartphone is reaching a plateau beyond which differentiation is tricky. But it could segment the market more than ever before, inadvertently extending the time between handset upgrades. If that's the case success in a smart watch may correlate with lower churn in smartphones, putting further pressure on Apple's competitors. Alternatively we may see a thriving market in Android compatible fake Apple Watches, mimicking the established business for fake Rolexes, though once again, this will only serve to devalue the brand of Android phones. There isn't really a good scenario for smartphone vendors once smart watches take off. And the fact remains that the most successful watch so far – the Pebble, it the one which is not made by a phone manufacturer. That may be indicative at least in part of a consumer reaction to being owned by a single manufacturer.

We've already seen Microsoft jump on the bandwagon with its Band [27] – "is it a Watch, is it a Fitness Tracker, is it a Mistake?" They will not be the last. It is possible that some may even come up with compelling offerings. Nor should we forget the traditional mainstream watch industry. They've been watching their market fade away for over twenty years and have put a lot of effort into reinventing the watch, probably none more so than Casio, with their successful range of G-Shock watches. They've recently released a smart watch – the less than enticingly named GBX6900B-1 which looks like a classic G-Shock, interacts with a smartphone and has a battery life of 2 years, which includes regular Bluetooth interaction with your phone [103]. Whether it is successful against the offerings from the phone manufacturers is yet to be seen. However, it's an excellent example of the fact that there are very experienced watch makers who are not going to sit by and see their remaining market taken away by what they consider to be upstarts.

An alternative approach to battery life is Kairos' T-Band [104], which is essentially a smart watch strap which can be fitted to any conventional watch. It's a very off-piste approach, asking users to look at a strap as well as their watch face, but it allows a larger battery, so it might just catch on. However, I suspect it needs to do a lot better than its current battery life of 2-3 days.

There another important strand in the evolution of smart watch sales, which is the ability of the Apple Watch to make payments using Apple Pay. It's another feature that Apple have introduced which

moves the concept of the watch beyond just being a wrist display for a smartphone. This is not the first time that secure, contactless payments have been tried in a phone, but the market conditions have changed. Credit card fraud is increasing and the payments industry is privately concerned that they're beginning to lose the cat and mouse struggle with the fraudsters. The problem is that rolling out a new, more secure payment scheme is immensely expensive. Europe addressed that back in the late 1990s with the introduction of Chip and Pin, but it has never taken off in the US. Phone vendors have been playing with NFC for the last ten years, but have never shipped enough interoperable, compliant phones to make it worthwhile for retailers to upgrade their Point of Sale equipment. That's the chicken and egg dilemma which has stymied any progress in the market. Apple has upped the bar by including this payment capability in the iPhone6. Although these will only be bought by a small portion of the market, they will probably sell at least 150 million units in 2015, growing to over 200 million in subsequent years as older non Apple Pay compliant handsets become obsolete. That is a critical mass which can persuade retailers to start upgrading their ePOS systems, beginning with high end stores frequented by the iPhone owning demographic before moving down into general retail.

There's been a long debate about whether it's easier to get a phone out of your pocket or handbag to pay for a transaction as opposed to getting a credit card out. That debate may now be irrelevant, because it doesn't get much easier than paying with your wrist. If Apple Pay compliant terminals become widespread across the world as a result of the critical mass of iPhone6s, then the next step of using your watch to pay may become a compelling new user experience, possibly even the most important reason for wearing a smart watch. The challenge for Apple will be to keep it to themselves. High end retailers may initially embrace it, but the wider retail market will not want to limit it to iPhone owners. Nor, if it decreases fraud, will the financial sector. They will put pressure on Apple to make it a more open standard, which will eventually remove it as lock-in benefit for the Apple Watch. I don't see that happening until around 2018, as banks don't move quickly. Until then, nothing is likely to put much pressure on Apple to reduce the price of their watch. As they lose that exclusivity, the price of the Apple Watch may finally start to fall. Whether competitors can then increase their pricing remains to be seen. It is a great opportunity for Apple, but by no means certain. However, if Apple stumbles along the way the whole smart watch sector may fall with it.

Which bring us to the numbers.

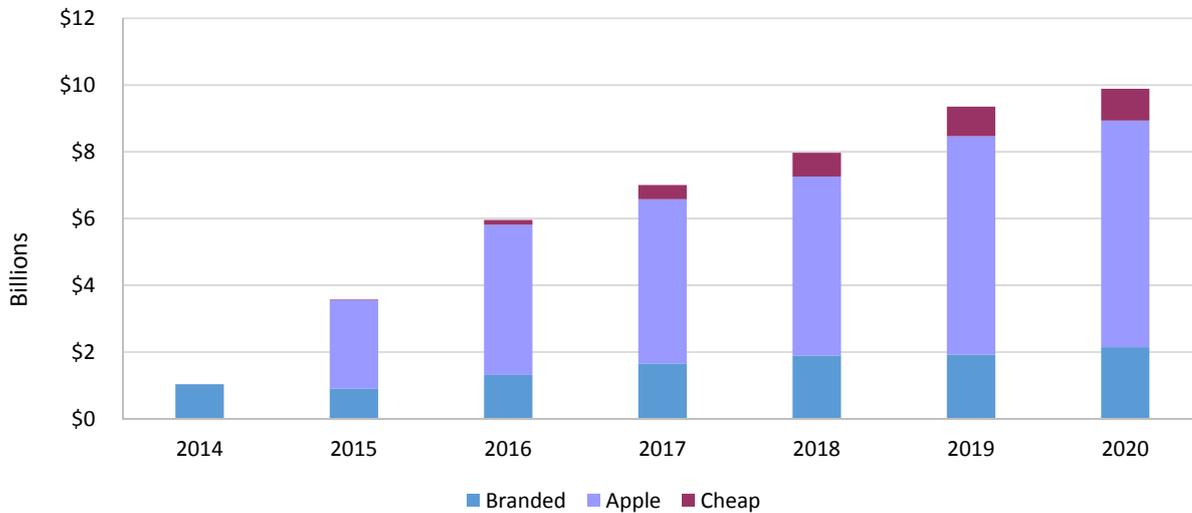


Figure 20. Global revenues for Smart Watches

2014 showed us what was to come. It was the foundational year, with Pebble growing and the big players pushing a surprising array of smart watches. A fair amount of the revenue had already been collected before the Apple Watch announcement, which should mean the market was around \$1 billion. In 2015 the Apple effect will push down price for its competitors as they try to clear stock and although volumes will continue to rise, not least because of the number of players, it will take many years to double to \$2 billion.

The cheap watches will dominate overall sales numbers from the second half of 2018, selling more than all of the other watches put together, But it will be a segment that runs on thin margins, putting something on the wrists of those who want a replacement for a cheap watch, not a mark of status.

The real revenue is once again with Apple. I don't expect more than about 16% of iPhone users to wear an Apple Watch, but they will be paying full price for them. After owning almost 50% of the market volume in 2015, it will slip to just over 20% by 2018, but it should then remain steady. However, they will take around 70% of the overall revenue for the sector. Could someone else challenge them? It's possible, but Apple has a key advantage of a single phone platform and updateable operating system which makes it easy to promote a watch experience that works for all of its customers. Every other handset vendor has a fragmented platform across many phone models making it far more difficult to reach critical mass. Nor do I see any competitor understanding user experience anything like as well.

If this scenario plays out, other vendors may attempt to differentiate their products by moving away from calling them smart watches. They will incorporate other sensors so there will be increasingly blurred boundaries between wristbands, gesture recognition bracelets, smart watches and child trackers. By 2018 the watch element will probably not drive the sale – it will simply be the standby state of the wrist worn device. That's another reason I like the Apple Watch – it really isn't trying to be a watch or a receptacle for technology. It's trying to be a new experience. For more dystopian readers, Ira Levin's 1970 novel "The Perfect Day" provides a chilling view of where the technology could end up [105]. It's probably no more fictional than any other prediction you'll read.

Sensors, Technology and Risks

Before summarising the opportunity it is worth a quick look at sensor technology, which is what is making the whole Smart Wearable market possible. Although the premise of this report is to try to look at the market potential from the user viewpoint, it has to be acknowledged that technical innovations have been responsible for bringing us to this tipping point. The start-ups we see innovating, either through crowd or seed funding are bringing disruption that is largely based on new technology innovations. Although the sensors in these devices generally get minimal publicity it is worth noting some of the underlying movement within this area, which will change the way that the market works. Over recent months there have been some notable injections of VC money and acquisitions which are leading to consolidation in key areas. Some of the more interesting one are:

- Valencell's C round funding of \$7 million. Valencell are a leader in miniaturising vital signs sensors for wearables.
- Audience's acquisition of Sensor Platforms enhancing its sound to motion control and gesture recognition.
- Invensense's acquisition of MovEA and Trusted Positioning to add context awareness to their sensor platforms. Invensense [106], along with Valencell have been responsible for the sensor solutions in many of the more adventurous smart wearable devices.
- ARM's investment in Sunrise Micro – enabling fast turnaround of new wireless silicon. As devices get smaller they will need rapid access to custom single chip solutions, which this partnership is well placed to deliver.
- Ineda Systems received \$17 million B round funding to develop the world's first dedicated wearable processing unit, allegedly reducing power consumption by a factor of ten.
- mCube received \$37m C round funding to develop sub-miniature MEMS sensors for wearables – what they are terming the Internet of Movables [107].
- Facebook's acquisition of ProtoGeo Oy, the company behind the Moves tracker app [108].
- Whistle acquired Tagg from Qualcomm and announces a further \$15m funding round, which includes Nokia Growth Partners and Qualcomm Ventures, showing growing interest and the start of consolidation in the pet arena [109].
- Sproutling raises \$6.6 million for making parenting less scary [110].
- Microsoft paid Osterhout Design – a company specialising in high tech wearables for industrial and defence use between \$100 and \$150 million for an IP portfolio related to wearable devices [111].
- PNI restructures to form a separate wearables and sensor companies PNI Sensor Corp and Precision Navigation Corp to allow more focus on wearable specific sensors [112].

- SiliconLabs acquisition of BlueGiga for \$61 million, strengthening their protocol expertise in Bluetooth Smart. They are well placed to supply integrated silicon to the wearables manufacturers [113].

Up until this point most of the enabling technology has been a by-product of the MEMS sensors developed for mobile phones. Some of the acquisitions and consolidations taking place indicate that companies are beginning to look at the Smart Wearable sector as a valid one in its own right, which needs different sensors. That's particularly true in haptics and in textile based development. Physical feedback will be important to drive development in smart clothing and there is still much work to be done to develop smart fabrics which look and feel like current fabrics as well as being able to be cut and made into garments without major changes in garment manufacturing techniques.

Wearable technology also makes it possible to experiment with some more immersive forms of sensing. An interesting development in smart clothing is the attempt to sense emotive state. No-one seems quite sure where this research is going, but the consensus seems to be that whatever is being detected it should be able to communicate it to others and clothing is the most obvious indicator that we wear. Concepts range from thermally sensitive fabrics to sensors from companies like OMSignal, a manufacturer of biometric clothing which has a fascinating vision of the brave new world of wearables which is worth investigating [114]. It's also worth looking at Studio XO's XO platform [114]. It offers "a new emotional technology platform that enables brands and artists to track users' emotional states, collect data and tailor services and experiences for both individuals and large audiences". At the moment all they offer is a wristband, but they're planning a wide range of on-body sensing and analysis. For some reason London seems to be spawning some of the most far-sighted smart clothing companies who seem to appreciate the need for end-to-end business models.

Much is made of the ease of designing wearables using standard platforms like the Android Wear initiative [116] and Mediatek's Linkit O/S [117]. I'm not convinced. These address the ease of developing apps for a platform, but wearables needs to transform hardware as well. In a sense this is just making the easy bit easier, diverting developers away from the harder but more important aspect of the physical form of the product.

Nor do I have much confidence in some of the open source initiatives aimed more at hardware. A good example is Atomwear [118], which managed to achieve \$13,740 of funding on Kickstarter. They're taking a modular approach to wristwear. It is unashamedly geeky, playing to the "look at me – I'm a quantified-self" user. It's not dissimilar to other modular initiatives within the open source / hardware community, but seems to be orthogonal to what the mainstream needs.

Samsung, Apple's potential Nemesis, has faced a dilemma in what to do in wearables, shunning the Android wear option in the hope of promoting their own wearable operating standard. They have positioned their mid-range Tizen operating system [119] in the wearable space for Gear Apps, where the lack of apps and hardware ecosystems that crippled it as a phone O/S may be less of a disadvantage.

A problem with all of the wearable O/S initiatives is that they are derived from mobile phone operating systems. They were designed for multi-threaded memory hungry phone platforms, not resource constrained devices running off coin cells. The wearable world needs a return to old-fashioned, optimised, embedded firmware, in many cases without an O/S. Unfortunately the people with these

skills are an increasingly rare breed, as young programmers have grown up with little experience of constrained systems. Most of those that the industry needs are approaching retirement. That poses a risk for wearable technology, but a good pension plan for a generation of embedded firmware engineers.

Beyond these risks, there are four invisible gorillas in the wearables changing room – data privacy, compelling experience, charging and cleanliness.

Data Privacy

Data privacy never bothered the founders of wearable technology – the quantified-self community. For them data was to be shared and the more there was to share, the better. Data was knowledge and the more shared knowledge that could be pooled, mined and analysed, the better it would serve society. Most of them made an active decision to share their personal data.

The vast majority of consumers may not agree. Most may not think about it until the consequences come back to bite them. Almost none will understand the amount of information and derived insight which can be extracted from a connected wearable device.

These same issues are starting to worry manufacturers. Already they are looking at the data from wristbands and wondering whether they have opened a Pandora's Box. At the most basic level they are seeing that the information they'd been given in focus groups about when people exercise has little relation to what they actually do, meaning decades of their marketing information is wrong. They didn't expect users to wear the bands twenty-four hours a day, revealing intimate details of their lives. The manufacturers know when the wristband wearer ate, when they went to the toilet, when they had sex and whether anyone else was there at the time. They can probably deduce if a man has a prostate problem or if a woman is pregnant earlier than that person would have known. None of these were covered in the implicit contract when the wristband was sold or in any terms and conditions. Manufacturers who are starting to analyse data, particularly for groups of users, are beginning to wonder how far they should go and what their responsibilities are? Should they inform a user of a potential medical condition? And what is their position if they can detect one but decide not to inform the user?

The sensible approach is to be open with consumers about their data and what it is being used for. Early adopters probably don't have a problem, but few users will comprehend just how much they are revealing. That means we will probably have to live through a number of media scares where data is lost or analysis performed which goes beyond the anticipated expectations of the users before society decides where the privacy line needs to be drawn. It is an emotive subject and a Sword of Damocles hanging over this new industry.

Compelling Experience

Compelling experience is going to be vital to speed up the acceptance and growth of wearables. In one form or another all of these devices harvest our data and feed it to applications that provide what we hope is compelling feedback. They are not just shiny objects of desire. We must never forget that for these products more than any previous technology products, emotion will drive demand. Companies

entering this market need to understand that. As well as hardware and software engineers and application developers they need to employ data scientists and behavioural psychologists. If companies don't breathe the tenets of B.J. Fogg and Robert Cialdini they may have problems keeping their users engaged. Without that engagement, any hope of successful service models is probably doomed.

Charging and Battery Life

Charging is a potential market killer. The best wearable will be one that never needs charging, or only needs a battery changed once a year. Designers need to understand this and ask what value an end user receives from the product versus the overhead of charging it. I believe there is a limit to the number of devices a user will charge each night, which will be a barrier for Smart Wearables. Wireless charging will help, but is not easily portable for travel. That may mean that users go back to choosing products based on battery life, as they used to in the early days of mobile phones. However compelling a product, if users have to invest too much in its maintenance, they will give up. That challenges the goal for wearables of filling consumers' wardrobes and drawers with multiple products which just work whenever they're taken out and put on. It may indicate that there is an interesting opportunity for redesigning clothes hangers as charging stations.

In time new battery technology will emerge, particularly for textiles. There is interesting work on woven and flexible batteries, such as a recent paper on fibre supercapacitors [120], but we will not see those much before 2020. In the meantime designers need to think about the problem and find ways to alleviate it. At CES 2015 Misfit demonstrated a nice, albeit upmarket solution of using a Swarovski crystal embedded in one of their devices [4] to focus light on a solar cell, combining fashionable upsell with practical efficiency. It's a nicely thought out solution. The earbuds from Earin show another novel approach to the problem [121]. But these are only chipping away at the very tip of the iceberg. There is much, much more which still needs to be done. Valencell's CEO Steven LeBoeuf has a pithy but well-turned phrase for it – "Death by Discharge" [122].

Cleanliness

Wearables share a common host with what else we wear – the human body. And as with clothes, if they are going to be practical, rather than just being occasional pieces of jewellery they will also get dirty. Most wearables come out of their box as shiny objects of desire, but quickly become tarnished and less desirable. Unlike phones, we won't keep them safely in handbags or pockets – we will expose them to the full range of wear and tear. That's particularly true for sporting devices and wearables for kids and pets.

The problem is that washing machines and electronic devices are not happy bedfellows, particularly if the wearable has connectors to allow it to be plugged in to be charged. It is not an insurmountable problem, but until smart wearables can be thrown into a washing machine with our clothes they will be relatively high maintenance products. Which means few people will be prepared to keep using more than one or two of them. Progress is being made. Cute Circuits claim that their latest fabrics with embedded LEDs will survive twenty machine washes at 30°C, which is a big step forward. Sensoria reckon their socks will withstand double that number, at forty washes. That's comparable with everyday socks, but at fifty times the cost of everyday socks, users may expect even more, at least if

they are to become mainstream

These four invisible gorillas are the gatekeepers of the Drawer for Forgotten Products which exists in every home. The drawer is already starting to fill up with wristbands. Collectively the industry must work harder than it has ever done before to ensure the drawer stays empty.

Conclusion

There is no doubt that there is a compelling market for Smart Wearable devices, although the relative value and growth opportunities of different sectors vary widely. From around \$600 million in 2013, it is accelerating. It should reach just over \$4 billion this year and exceed \$14 billion in 2017, then double to reach \$30 billion in 2020. Almost half of that will probably come from companies that are not players in today's consumer electronics market.

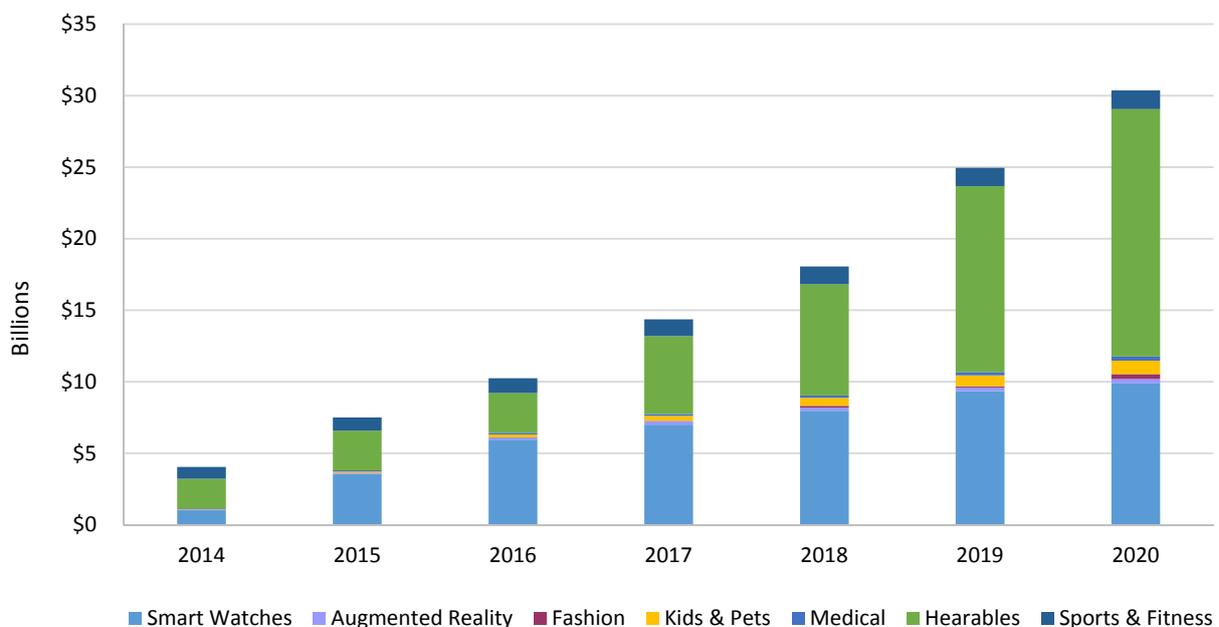


Figure 21. Global Revenue from Smart Wearables

For the next few years smart watches will dominate sales, but from early in 2018, hearables will begin to overtake them. After that, hearables will grow more strongly than smart watches. The only sector which looks as if it could challenge either is smart clothing, but in this timeframe only if social clothing for sports fans takes off. That will put pressure on technology to deliver – the big opportunity is probably a few years later in the 2022 World Cup, when smart clothing and the associated subscription revenues could overtake any other sector. But that's too far out to include.

2014 was a year for experimenting. 2015 should be a more formative one, when we will see whether the initial purchases found favour with consumers or whether they dismiss the whole sector as unnecessary. However, there is enough diversity of ideas, products and companies to see more

innovation than we have ever seen before in consumer electronics. How it will turn out is difficult to predict, but the ride will be fun.

There are a few more resources that are worth keeping an eye on. There is a fascinating history of wearables at MIT [123], a growing database of wearable devices (not all of which are smart) maintained by Vandrico [124] which is far more comprehensive than this report could ever be, and an amusing NSFW take on wearable company strategy [125] by Daniel O'Connell which everyone in the industry should read.

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This article, along with other reports and market commentary is available on the Creative Connectivity website at <http://www.nickhunn.com>.

An expanded version of this report, with shipment volumes for each category and revenue projections for service models will be published for purchase as:

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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 Appcessories, Wearables and the Internet of Things. Nick has an M.A. from Cambridge University and can be contacted at nick@wifore.com. His blog, where more articles are available is at www.nickhunn.com.