The Complete Guide on the Cost to Develop, Scale, and Manufacture Your New Electronic Product

hackster.io

PREDICTABLE DESIGNS

Dragon Innovation

Newark

Table of Contents

$1,000 or $10,000 or $100,000 or $1 Million, or Even More?

Unless you've done it before you likely have no realistic idea on how much it costs to develop, scale, and manufacture a new hardware product. I mean, why would you, right?

The large majority of entrepreneurs drastically underestimate the cost required to get a new product on the market. This is one of the main reasons so many hardware startups ultimately fail.

The cost to get your product from concept to market can be split into three categories: development costs, scaling costs, and manufacturing cost. There are also other operational business costs such as salaries and marketing expenses that I don't cover in this guide.

Development costs are what most entrepreneurs focus on because they are the first financial obstacle. Development costs consist mostly of engineering fees and prototyping costs. This gets you to the point of having a production-quality prototype.

The next cost you'll face is the scaling cost, which is the cost to scale your product from a prototype to a mass manufactured product. This includes the cost to set up your manufacturing process and to obtain electrical certifications, patents, etc.

Arguably the most critical cost is the actual cost per unit to manufacture your product. This cost is so important because it determines your profit and your sales price. You'll eventually get past the development and scaling stages, but you will be dealing with production for the life of your product or company.

For extremely complex products the total costs may reach millions of dollars. The original iPhone is said to have cost Apple about $150 million to develop and scale! Thankfully, most products aren't nearly this complex or expensive to develop.

Don't make the fatal mistake of underestimating the costs, or worse yet not estimating them at all, because in order to succeed to market it's necessary to know your costs as early as possible.

Without knowing all of the costs you'll either run out of money before your product is market-ready, or you'll find yourself developing a product that can't ever be manufactured profitably.

Development Costs

Development costs for most hardware products can be broken down into three categories: the electronics, the enclosure, and the retail package. The electronics is what does all of the magic, the enclosure is what holds the product together, and the retail package protects and sells the product.

Electronics Cost

The electronics will usually be the most complex and expensive part of your product to develop. Engineers aren't cheap. Especially good ones. Unless you are lucky enough to be an electronics design engineer you will need to hire an engineer to develop the electronics.

In the United States you can expect an electronics engineer to cost you between $100 to $200 per hour with most charging close to $125/hour. Lower cost engineers in other countries commonly charge around $50/hour or less.

The engineering required for the development of the electronics can be broken down into several steps: system architecture, components selection, schematic diagram, PCB layout, programming, and debug.

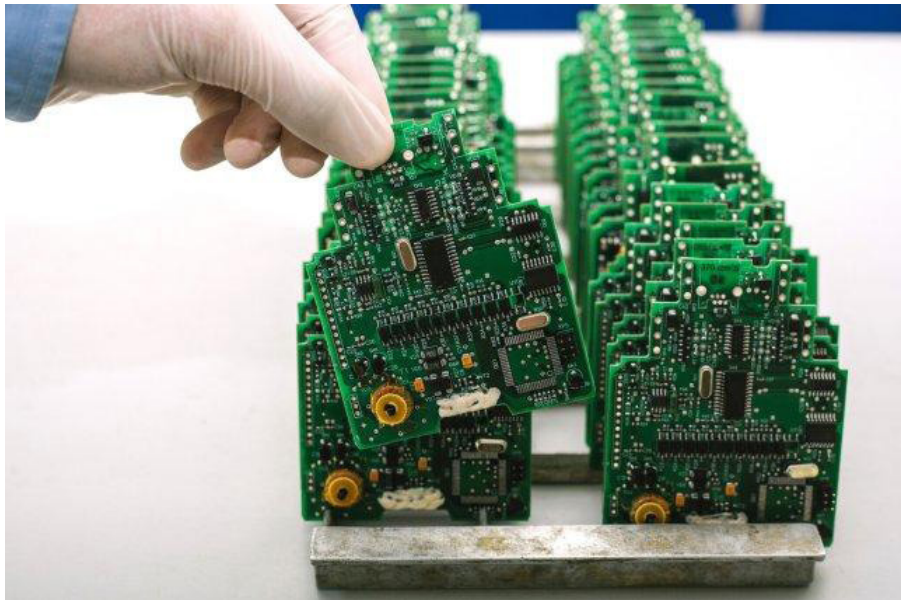
Prototyping the electronics is divided into two steps: production of the blank printed circuit board (PCB) and soldering of all the electronic components onto the PCB. The PCB is what holds and connects all of the individual electronic components.

The cost of the blank PCB is mostly determined by its size and the number of routing layers. At a bare minimum two routing layers (top and bottom) are required; however, most designs will require from four to six layers. More complex designs may require eight layers or more. Increasing the number of layers generally allows you to reduce the overall size of the PCB.

Although the use of complex PCB technologies such as blind and/or buried vias will reduce the board size, they also drastically increase the board cost. Their use will typically double the PCB prototype cost, so in most cases it's best to use only standard through-hole vias.

The cost to assemble the PCB (i.e. solder down all the electronic components) is primarily determined by the total number of components, the minimum pin pitch, the use of leadless packages such as QFN or BGA, and whether components are soldered on both sides of the PCB.

For most products producing the blank PCBs will be about a third of the electronic prototyping costs, and the board assembly will run about two-thirds of the cost.



I usually recommend starting off with about three to five boards, then potentially increasing the quantity for each iteration. Once you've confirmed functionality and worked out most of the major bugs then you can increase the prototype quantity and begin sharing with them with investors and potential customers.

Enclosure/Mechanical Development Cost

Unless your product will be marketed strictly to the maker market it will require some type of enclosure, which is usually made of plastic. You can expect to spend at least several thousand dollars to develop the 3D models for enclosure. If appearance and ergonomics are critical for your product then the cost to design the 3D model will be higher.

Some products may require additional mechanical parts such as stamped metal components, or perhaps even moving parts. This will add additional costs for mechanical engineering and prototyping.

Prototyping of the plastic enclosure is most commonly done using 3D printing technology. 3D printing builds a custom shaped part by stacking layers of molten plastic.

The popularity of 3D printing has really helped to bring down the cost of creating plastic prototypes. For some startups purchasing your own 3D printer may be the most cost-effective strategy.

For a few products a technology called CNC machining may be a better choice than 3D printing. Unlike 3D printing which is considered an additive process, CNC machining is a subtractive process. Instead of stacking layers, as with 3D printing, CNC machining is similar to sculpting. The process starts with a solid block of plastic and material is removed to form the final shape.

The main advantage of CNC machining is that it allows the use of production injection-molded plastic whereas 3D printing uses special prototyping plastics that may have a different look, feel, and strength, compared to the production (injection molded) plastic that will ultimately be used.

My own product required several precise snap fits so it was critical to use the same plastic as used for production. So in my case CNC machining was the better choice. However, for the majority of products 3D printing will be the better technology.

One word of caution when it comes to plastic, what can be prototyped can't necessarily be manufactured. This is especially true with 3D printing. With 3D printing there are few limitations on the shapes that can be created.

However with production injection molding technology there are complex limitations on the shapes that can be produced. So make sure you hire a 3D model designer that understands injection molding, otherwise you may find yourself with a prototype that can’t be manufactured without a massive redesign.

Retail Package Development

Many hardware entrepreneurs neglect the importance of developing the retail package. This is a major oversight with serious consequences. Unless you plan to only sell your product online, or to industrial customers, the retail package is just as important as the product itself. Sometimes even more important.

You can have the greatest product in the world but if your retail package doesn't quickly convey this to the customer it won't sell. Always remember, nothing matters without sales!

There are generally two types of retail packages used for electronic products: clamshells or boxes. Smaller products tend to commonly be packaged in clamshells, whereas larger products favor retail boxes.

Both clamshells and retail boxes usually consist of two pieces: a custom shaped plastic piece to hold and protect the product, and a cardboard artwork piece to convey your sales message.

Just as with your product's enclosure, the custom shaped plastic part of the package will require a 3D model be developed. Then an injection molds will need to be purchased.

For clamshells, one cost-saving trick is to use a stock clamshell with a custom molded blister (the part of the clamshell that custom fits over your product). The molds for a custom blister will be much cheaper than molds for a fully custom clamshell.

The clamshell insert card can initially simply be printed on regular paper prototypes, but eventually you'll want to upgrade to a thicker card stock which requires stamp printing.

Scaling Costs

Having finished prototypes of your product is a major accomplishment so congratulations! But don't get too excited. It's a HUGE step to go from prototype to large volume production. It's probably one of the most underestimated steps in launching a new hardware product.

Most electronic products require multiple certifications in order to be sold. The certifications required depends on the product specifics and the countries in which it will be marketed.

The cost and time needed to obtain all of the certifications necessary for your product is one of the most overlooked steps to bringing a new hardware product to market.

Certifications may not be the most captivating subject, but to succeed it's essential you understand the certifications required for your product.

We'll mainly discuss certifications necessary in the United States, Canada, and the EU. However, other countries and regions will have very similar requirements.

Federal Communications Commission (FCC)

Federal Communications Commission (FCC) certification is required in the United States for all electronic products that oscillate at 9 kHz or higher. This regulation falls under what the FCC calls “Title 47 CFR Part 15” (15th subsection of the 47th section of the Code of Federal Regulations).

In Europe, there is a similar regulation called CISPR 22. The requirements are very similar, but somewhat stricter in regards to RF emissions at some frequencies. Other countries and regions have similar regulations on electromagnetic emissions.

For all intents and purposes, these regulations include almost all electronic products, since very few products are able to run at frequencies less than 9 kHz.

However, if your product is simple enough you may be able to bypass FCC certification by purposefully designing it to operate below 9 kHz. For example, some microcontrollers can be run at frequencies below 9 kHz.

All electronic products with oscillating signals will emit some amount of electromagnetic radiation (i.e. radio waves) so government regulators want to make sure that products don’t interfere with wireless communication.

There are two classes of FCC testing: Class A and Class B. Class A is an easier test to pass and is intended for products that will be used in industrial applications. Class B is for consumer products and requires stricter testing.

Further, FCC certification can be split into two types: intentional radiator and non-intentional radiator. The category is determined by whether your product incorporates wireless capabilities such as Bluetooth, WiFi, cellular, or any other type of radio transmitter.

The FCC classifies an intentional radiator as any product that intentionally transmits radio frequency (RF) waves

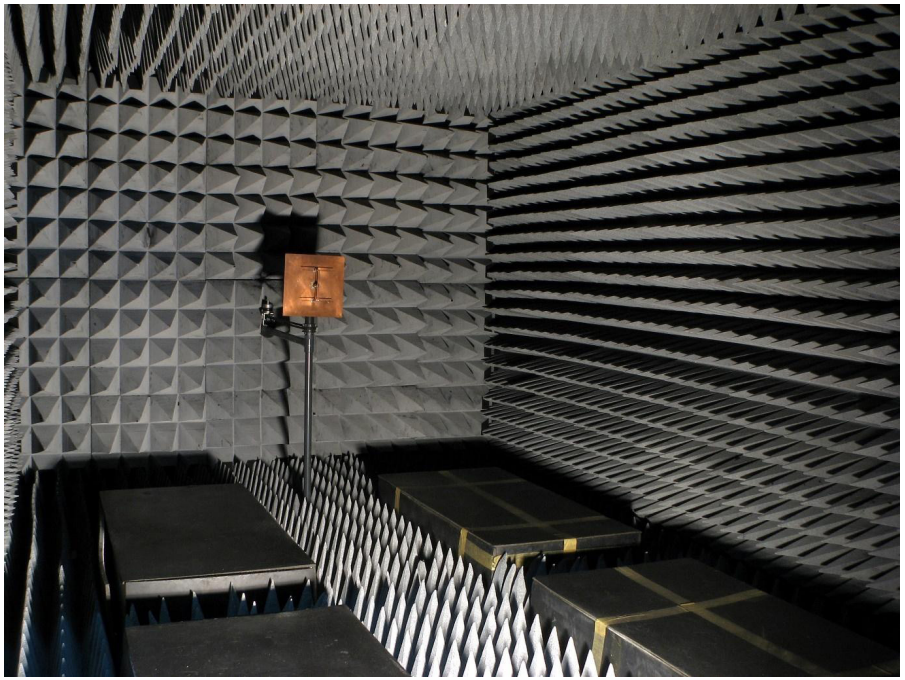
(also called more broadly electromagnetic radiation). A cellular phone or an Internet of Things (IoT) device are examples of intentional radiators.

A non-intentional radiator is classified as a product that doesn't intentionally emit radio frequency waves. Any electronic product will emit some level of electromagnetic radiation. Intentional radiator certification is more involved and more expensive.

For this reason, you should use pre-certified modules for any wireless functions. This will save you the extra cost for intentional radiator certification since your wireless functions will be performed by the pre-certified modules. Doing so will save you thousands of dollars.

Electromagnetic emissions are measured using a specialized testing chamber called an anechoic chamber ("an-echoic" or non-echoing) which is a specialized room designed to absorb all electromagnetic radiation. The chamber is outfitted with sensors for detecting electromagnetic emissions.

The cost to rent a testing chamber is one of the primary costs of obtaining FCC certification. The rental cost for one of these chambers can be up to around $1,000 per hour. At a minimum, each testing session will take a couple of hours. The majority of products require several sessions in order to pass.
Most entrepreneurs choose to hire a third party certification testing company such as Intertek or SGS to perform all of the necessary FCC testing.



An anechoic chamber for measuring electromagnetic emissions.

Typically, you will need to make some modifications to your electronics design in order to pass the emissions testing. This includes such things as adding ferrite beads, capacitors, shields, and other modifications to reduce emissions at all but the intended frequency.

UL (Underwriters Laboratories)

UL certification is necessary in the United States and Canada if the product plugs directly into an AC outlet. Primarily the UL is concerned with the electrical safety of your product.

This certification is to ensure that your product doesn't start an electrical fire, or cause other safety issues.

Technically, UL certification isn't absolutely required to sell your product in the U.S. But, if the product does plug into an AC electrical outlet you would be crazy to not get this certification.

If a fire is started by your product and you don't have UL certification, you will be held liable.

Even if no one is ever injured by your product, obtaining a UL certification can help eliminate potential failure mechanisms.

Working through the various design issues and obtaining the UL certification may help to significantly reduce the number of potential product failures.

Passing these various certifications, whether mandatory or not, helps to make your product more robust and less likely to have any problems.

You don't want to have the issues like Samsung had with their Galaxy Note 7 phone where it was constantly catching on fire. Regardless of the size of your company, recovering from these types of failures can be next to impossible.

UL certification is not necessary for products that don't plug into an AC power outlet. But, of course, most battery powered products need to have their battery recharged.

The key to avoiding the UL certification requirement in this case is to make it so your product uses a pre-certified stand-alone charger.

So, for example, if your product can be recharged by a USB charger, then the UL requirement falls on the charger itself and not necessarily on your product.

In this case you could either purchase a pre-certified USB charger to bundle with your product, or you could require the customer supply their own USB charging source.

The same is true if your product uses a non-USB charger such as a wall adapter power supply. In this case, once again the UL certification requirement falls on the wall adapter since it plugs directly into the AC electrical outlet.

Your product will never see that AC voltage since the wall adapter converts it down to a low DC voltage.

Most product liability insurance companies, as well as most large retail chains, will require that your product be UL certified even if it doesn't plug directly into an AC outlet. Most larger retailers will require it just as an extra margin of safety.

This is one reason that many entrepreneurs begin by selling their product directly to consumers via their own website. Doing so may allow you to minimize the number of certifications required.

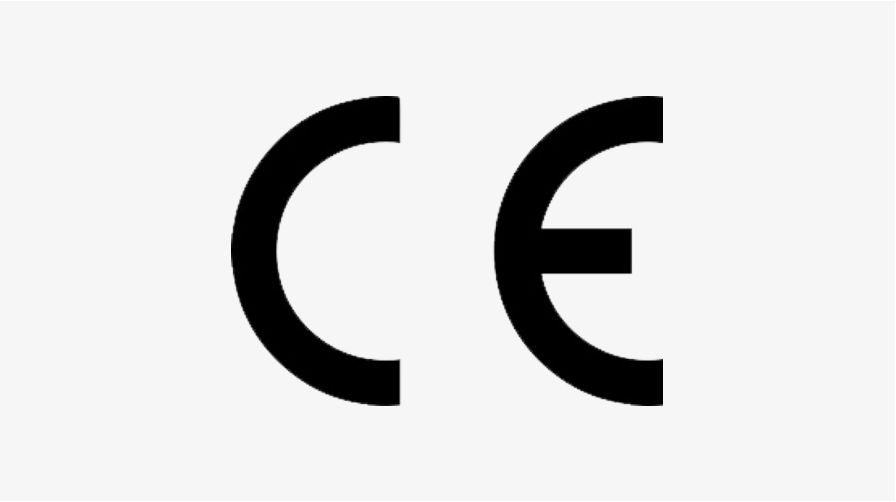
UL certification can be quite complex and confusing because of the numerous types of UL certifications.

If your product does plug directly into a AC electrical outlet then I highly suggest you bring on a UL expert to review the design before you proceed too far with development.

CSA (Canadian Standards Association) is an alternative to UL certification and is valid in both Canada and the United States.

MET Laboratories is another alternative to UL certification. Although not as well-known as UL, MET Laboratories is also a Nationally Recognized Testing Laboratories (NRTL) approved in the U.S. by OSHA (Occupational Safety and Health Administration). Consider CSA or MET certifications instead of UL in order to reduce your certification costs.

CE Marking



CE marking is required for the majority of products marketed in Europe.

CE is an abbreviation for the French phrase Conformité Européenne which translates to European Conformity. Originally called an EC Mark, this certification officially became known as a CE Marking in 1993.

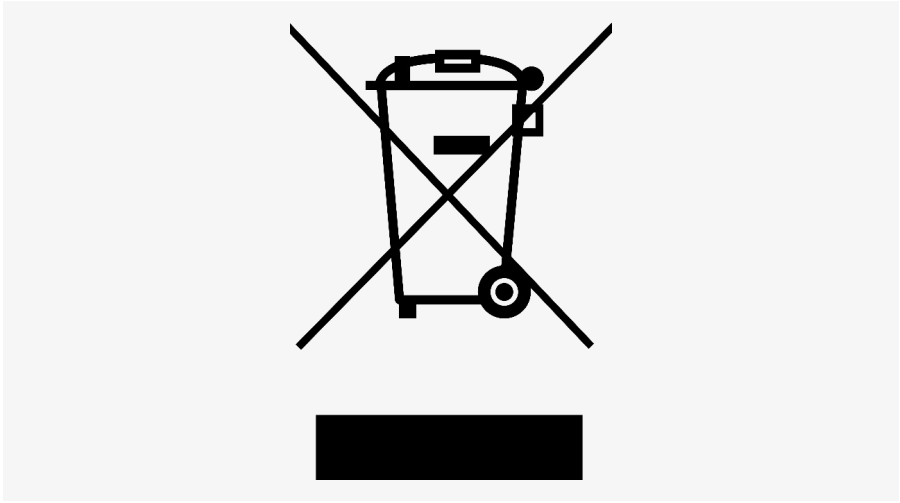
The CE marking on a product is a manufacturer's declaration that the product complies with the health, safety and environmental requirements in Europe. It is quite similar to a combination of the UL and FCC certifications.

RoHS Certification

RoHS certification verifies that a product contains no lead. It's necessary for products sold in the European Union and the state of California. Since most products are sold in California and/or Europe their requirements have become de facto standards for environmental regulation.

RoHS is one of the easiest and cheapest types of certifications to obtain. In fact, you may find this is something your contract manufacturer will do for you.

Waste Electrical & Electronic Equipment Regulation (WEEE)



The Waste Electrical & Electronic Equipment (WEEE) regulation is a directive in the European Union that designates safe and responsible collection, recycling and, recovery procedures for all types of electronic waste.

WEEE encourages the design of electronic products with environmentally-safe recycling and recovery in mind.

This regulation works in conjunction with RoHS. RoHS regulates the hazardous materials used in electronic products, and WEEE regulates the safe disposal of the product.

Bluetooth SIG

Although not technically a certification, if your product incorporates Bluetooth Classic or Bluetooth Low Energy, then you must have it tested and “certified” in order to use the Bluetooth name/logo on your product.

Bluetooth SIG is an non-profit organization that oversees the Bluetooth standard and licensing of the Bluetooth technology trademark. You need to register and have your product tested in a certified lab. You must also pay to use the Bluetooth trademark. Unlike the other certifications, this is an international certification.

Even if your product implements Bluetooth using a pre-certified module you will still be required to obtain the Bluetooth SIG certification.

The normal Bluetooth SIG fee is $8,000 USD. However, they also offer a lower cost option specifically for startup companies that costs only $2,500 USD. To qualify you must show financial documents proving that your annual revenue is less than $1 million dollars.

Other Certifications

Some types of products will require even more certifications. For example, toys have a very comprehensive list of required tests and regulations to ensure they are safe for children.

Or, if your product comes into contact with food then you'll need to follow FDA guidelines on what materials can be safely used.

Because lithium batteries have the potential to cause a fire hazard (think Samsung Galaxy Note 7), there are regulations on the shipment of lithium batteries. The air shipment of lithium batteries is especially restricted.

Many startups plan to market their product globally without understanding that they need capital to pay for added regulatory tests for each country. I highly recommend that you focus your initial efforts on a single country or region, then expand slowly from there.

The U.S. and Canada share similar certification requirements so in most cases you can sell your product in both countries with a single set of certifications. The EU has the advantage that one set of certification requirements are valid for multiple countries.

Asia on the other hand tends to have separate regulations for each country. Unless you live in Asia, marketing a product there will only be a viable option once you are a significantly sized company with people on the ground there.

Although you don't want to actually begin the certification process until you have a production-quality unit for testing, it's still a good idea to start understanding the various issues surrounding certifications as soon as possible.

Manufacturing Setup Costs

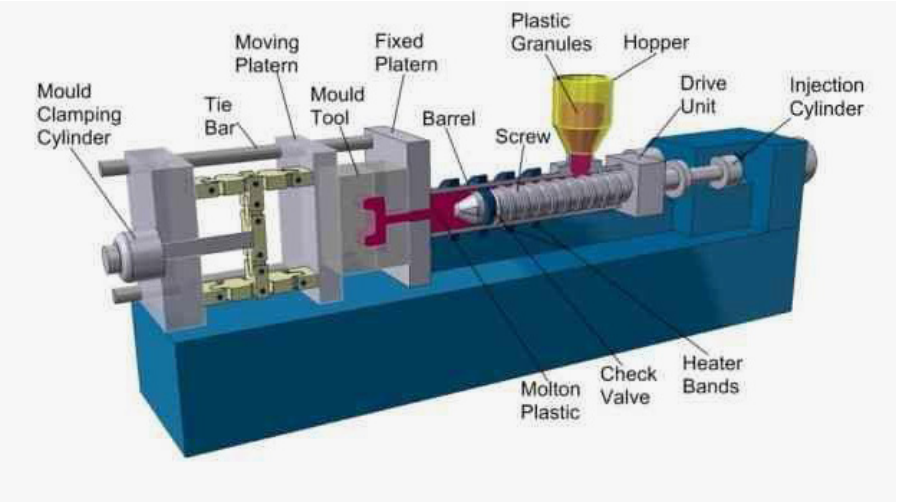
Any injection molded parts needed for your product (enclosure, retail package, etc.) will likely be one of your biggest costs. Injection molds, especially those used for high volume manufacturing, are very expensive.

Just about any product will require at least three molds (front and back side of enclosure plus one for the retail package); however, most products require four to six molds.

Mold cost is mostly determined by the hardness of the metal used (higher volume molds use harder steel), the number of cavities, and the use of any side actions. In most cases it's best to start with a single cavity mold that uses a softer steel, and that is considered a simple pull mold (meaning no side actions are required).

For more details on injection molds see part 3 of my Ultimate Guide - How to Develop a New Electronic Hardware Product.

The electronics will likely be the most expensive component of the product to develop, but it will be the plastic that is the most costly to scale because of the high cost of injection molds.



Pictorial of an injection molding machine (supplied courtesy of Rutland Plastics)

An injection mold consists of two pieces of metal that are pushed together using high pressure to create a cavity in the shape of the desired part. Then, molten plastic is forced into the mold. The main advantage of injection molding technology is that it's a fantastically cheap method of producing millions of copies of a plastic part.

There are two big downsides to using injection molding: the high cost of the molds that I've already mentioned, and the limitations on the shapes that can be produced. The high mold cost is mostly due to the fact that the molten plastic is injected over and over at extremely high temperature and pressure. This means the mold must be incredibly durable.

To tolerate these extreme conditions injection molds are created using a hard metal such as steel. The more injections the mold must tolerate, the harder it must be and the higher it's cost.

For example, you can use aluminum molds to make a few thousand units. Aluminum is soft so it degrades very quickly. However, it's also much easier to machine (i.e. carve) into the desired shape, so its cost is significantly lower. As the required volume for the mold increases so does the necessary metal hardness and therefore its cost increases.

A single-cavity mold made from a softer metal may cost a couple thousand dollars and be good for a few thousand units. Whereas, a multi-cavity mold made from a really hard metal can potentially pump out millions of units, but it will cost you tens of thousands of dollars, perhaps as much as $50,000.

Landed Production Cost

No doubt about it, the **landed production cost is your most important cost**. It tells you how much inventory will cost, how much you can sell your product for, and how much profit you can make! Also, unlike the development and scaling costs, it's a cost you'll continually face for as long as your company exists.

The landed production cost is the total cost to produce and transport a single unit to your warehouse. If you are successful, you will have a very long, intimate relationship with this number. You will always be striving to reduce this cost so you can ultimately make more money.

For most products you can estimate that your suggested sales price will be three to five times your landed production cost.

Inventory is always one of the biggest costs for hardware companies. Your inventory cost is just your product cost times the quantity. So in order to estimate your inventory costs you need to first know your production unit cost.

Needless to say you need to know your landed production cost as soon as possible. There's no point in spending years developing and scaling a product that can't ever be manufactured and sold at a profit.

Some of the many costs included in the landed production cost include:

Electronic Components
For electronic hardware products the cost of the electronic components will likely be the most difficult to accurately determine. This is because considerable engineering design work is necessary in order to know which components are required for your product.

A lot of startups wait until their product is completely designed and prototyped before they try to determine their components cost and ultimately the production cost. This is a mistake because you really need to have an estimate of this cost BEFORE you spend tens of thousands of dollars developing the product.

There may be some desired features for your product that you determine are too expensive to include in your first version. By estimating your components cost upfront you can avoid developing a feature that isn't profitable or necessary initially.

PCB Production and Assembly
Just as with your prototypes, producing the electronics is a two-step procedure. First the blank PCB is produced, and then all of the electronic components are soldered onto the board.

The cost of the blank PCB is primarily determined by its size and the number of routing layers required. A minimum of two routing layers (top and bottom) is required; however, most products will need four to eight layers.

The cost to assemble the PCB is mostly set by the number of parts, the minimum pin spacing, the use of leadless packages, and whether components are attached to both sides of the board.

Keep in mind that the cost to produce your assembled PCB in volume will be many times cheaper than the per unit cost of the prototypes. Much of the cost is the initial setup so as the volume increases the setup cost becomes minimal. That being said the setup costs for the electronics pale in comparison to the setup costs for the plastic (i.e. the injection molds).

Injection Molded Plastic Parts
The cost you'll pay per unit for any production plastic pieces is primarily determined by the weight, size, mold time, and type of plastic used. The size and weight for each piece is dependent upon your design so there isn't much you can do to control those variables short of making your product smaller or less durable (thinner plastic).

You can eventually increase your production speed, and reduce the part cost, by using multiple cavity molds. A multi-cavity injection mold allows you to produce multiple copies of your part with a single injection of plastic. But they also significantly increases the mold cost. Don't jump into buying multiple cavity molds until you have worked through any tweaks or changes to your initial molds. It is wise to run at least several thousand units before upgrading to multiple cavity molds.

Increasing the number of mold cavities is usually the best method for reducing the plastic part cost since size, weight, and the type of plastic directly impact the end product.

Other Mechanical Parts
Some products will require various other parts such as stamped metal pieces (for internal shields, etc.), springs, gears, screws, motors, and so forth. The production cost

for these types of parts will commonly be comparable to the cost of any similar size custom plastic pieces which a price of several cents. However, their scaling costs will typically be considerably less since no expensive injection molds are required. In most cases, stock components can be used which will eliminate any scaling costs.

Final Product Assembly
Once the various individual components are ready the next step is to assemble them to form your final product. The cost of this step is almost entirely labor costs. This means eventually you're likely to need to have final assembly completed at a location with low wages such as Asia.

Testing
Once the final product has been assembled it needs to be tested to confirm it is fully functional and meets all of the quality specifications. Some testing of the electronics may also be done before final assembly so as to prevent wasting the cost of final assembly for a unit that has problems with the electronics. As your scrap rate decreases you'll likely perform all testing after the final assembly is completed.

Improper testing, and ultimately shipping bad units to customers, is a common mistake made by new startups and one that can spell death. Entrepreneurs tend to many times be in a rush to get their new product to customers but shipping bad units will start your company off with a bad reputation which can spread quickly online.

Scrap Rate
No manufacturing process is ever perfect and you are guaranteed to have some faulty units. Initially this may be 10% or more, but as time goes on and you optimize your manufacturing process you should be able to reduce this number to only 1-3%.

Packaging
Packaging costs depends on whether your product will be selling in retail stores, or primarily online. For products being sold in retail outlets having optimal retail packaging is a critical priority so packaging costs will be significantly higher. The packaging cost can generally be greatly reduced if you plan to only sell your product online, via TV, or to industrial customers.

High-end retail packaging (i.e. full color boxes with custom plastic inserts) can be really expensive (costing as much as $5 to $10 each) so in most cases it's best to start off with more simple packaging to minimize your costs. This is one reason it may be best to focus initially on online sales.

Don’t forget to include the cost of the master carton that will be used to ship your packaged product. The master carton cost is typically quite low since it usually just a cardboard box and the cost gets split between multiple units. Nonetheless, it’s important to include it in your cost calculations.

If your product requires a retail display stand then that can add another cost to your package cost calculations.

Returns
Just like you are guaranteed to have some faulty units that must be scraped you’re also guaranteed to have at least a small percentage of unhappy customers that wish to return their purchase. So be sure to include this in your final production cost. Just as with the scrap rate your return rate should decrease as you optimize your product, packaging, and customer service.

Freight
Most products will be ultimately be manufactured in Asia. This means your finished product will first need to be trucked from the factory to local seaport. Then it will be loaded on a cargo boat for shipment to your target country. In rare cases you may wish to ship via air cargo, but the cost will be significantly higher than shipping via sea. Once the boat arrives in your country you’ll now need to truck it from the port to your warehouse or directly to your customer.

For shipping via truck it’s the weight that primarily determines the shipping cost, and for shipping via boat it’s the volume that determines the cost.

Duties
Don’t forget the taxes. Both the country of manufacture and the country of import will charge duties which need to be included in the final landed cost. Although, some product categories may be exempt from export and/or import taxes. Each product classification has a number known as a Harmonized Tariff Schedule (or HS code). Once you’ve determined the HS code for your product then you can look up the export and import duty rates.

Conclusion

The cost to launch a new electronic product can be overwhelming, especially for entrepreneurs and startups. Development costs will be your first financial obstacle to surpass, and scaling costs will be your largest early cost obstacle. However, the landed production cost will definitely be your most important cost since it determines your profit, sales price and inventory cost.

You'll eventually move beyond the development and scaling costs, but you'll have to live with the production/inventory cost indefinitely as long your company exists, which hopefully will be for very long time.