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Product Development Steps and Timeline

You should plan on constant, dedicated effort for twelve to eighteen months—in some cases even longer—with a complete team, in order to go from a well-defined product idea to a finished product that is ready to ship. It is impossible to anticipate all delays and complications, so be prepared for these setbacks from the start and schedule a realistic timeline with this in mind.

Rich LeGrand, president of Charmed Labs, which develops and sells innovative robotics technology, might advocate budgeting even more time. Their Pixie robotic camera was the star of a 250,000 dollar Kickstarter campaign in 2013. Rich reflects on how long it actually takes to develop a product: “I hate to think of this, but it typically takes [us] two to three years. At the beginning, it almost always seems like it will take half the time it actually takes.”

To understand what sort of roadblocks you might encounter, take a look at some of the funded design projects on Kickstarter. Scroll through the updates and check out the explanations for delays in the schedule. These are all normal, and your project will be no different. Before crowdfunding, these delays were opaque to the consumer because the process was hidden inside corporations until they were finally ready to launch. And on top of the public scrutiny that crowdfunding is subjected to, product development delays in that arena are often compounded by an inexperienced founding team and underestimated budget requirements.

Sources for delays include potential manufacturers overpromising what they can deliver; it is easy to simply underestimate the complexity of various parts that will end up requiring revisions and adjustments. And these adjustments might come after the time that you had planned for them to be in full-scale production. I backed the Tiko 3D printer on Kickstarter in March of 2015 and it was scheduled for delivery in November of that same year. At that time, the founding team was small and competent, yet inexperienced, and they had a working prototype. A critical component of their design was a plastic extruded chassis that contains precise rails for a gantry system, and their manufacturer had indicated that it should be no problem to make. They related their manufacturing difficulties in an update as that year came to a close. They had started extruding the chassis in May but it had come out as a crooked, ugly, and inaccurate mess. Finally, by the end of that year, they had achieved the chassis quality that the design required, but they were still nowhere near delivering their product as scheduled. And that was only one of many manufacturing challenges for the project. They finally delivered some partially functioning printers more than a year later (I never did receive mine), but then the company was forced to lay off their team and wind down operations in 2017 after their funding—just under three million dollars—had dwindled to almost nothing. Two years would have been a reasonable time to deliver such a product, but their planning and budgeting was so far off that they fell short. They later acknowledged that they were unprepared for how hard it would be to go from a prototype to full manufacturing, and by the time they realized they were in trouble they were unable to turn the company around. The outcome might have been different if they had set a more reasonable timeline from the beginning to allow for all the engineering and production iterations it takes to deliver a mass-produced product.

So, taking caution, let us now look more specifically at the steps and timeline for delivering such a product. This outline would be for a handheld-sized consumer product. Let's use the mustache comb as an example. First, why an Internet-connected mustache comb? Absurd! Indeed it is. (That's right; we are leaving the market analysis to another book.) Let's claim that the comb monitors mustache health and uploads the data to a personal facial hair grooming app. This indispensable tool is comprised of several parts. The body of the comb is injection-molded plastic. The design will depend on a research phase to be sure that the handle is comfortable to hold and that the teeth are spaced just right. We don't want to take anything for granted or to simply copy what has been done before. There will be a hollow in the comb that contains a small printed circuit board (PCB) and a wireless module along with a battery. We will specify a small, energy-dense battery that will fit into our limited space. We will have a waterproof cover that caps the PCB to protect it from any moisture during our morning ablutions.

We will also have to figure out how to waterproof the single tiny button and the blinking LED that are part of the design. We plan out our schedule according to this outline:

Design and Engineering	3-6 months
Validation and Testing	1-2 months
Find and Vet Manufacturers	2-3 months
Manufacture the Tooling	6-12 weeks
Produce First Parts, Adjust Design	2 weeks
Manufacture Production Parts	2 weeks
Regulatory Testing	1-2 months
Assembly and Packaging	2 weeks
Shipping and Customs	1-2 months
Fulfillment to the Customer	1 week

No doubt you are making a mental note of your own timeline. Resist the urge to squeeze down your delivery forecast to less than twelve months. Reality will surely intervene and push that release date back out.

John Kestner, the principal of Supermechanical, a company that makes connected home products, gives these pointers for managing the product development cycle:

> Even if you're an organized person, there are way too many small things demanding your attention in something this complicated. You have to use a project management app with Gantt charting (Microsoft Project, OmniPlan, TeamGantt) to turn a huge project into a series of tasks, assign them to your team, and tell you where the trouble spots are. Check weekly that everyone's on track and be honest with yourself about your progress

> as you update your schedule. And things will always take longer than you want, but especially when you make changes mid-stream. Reduce that likelihood by minimizing the number of challenging features in a given product. Save the rest for version two.

Kestner describes his design process with an eye toward manufacturing:

> Every product, I learn something I could've done at the beginning of the process that would've saved me time, money, and grief at the end. Manufacturing is one of the constraints that you want to solve for in order to make the most elegant and complete product . . . Design for assembly, fulfillment, and marketing are also in my head when I sketch . . . It's multi-dimensional chess—fun and challenging.

Despite all the complex tasks you will have to attend to throughout the process, much of the heavy lifting to make production go smoothly starts early with design and engineering. Beginning with savvy industrial design will result in a product that is both useful to the consumer and reasonable to manufacture. This earliest phase is not necessarily concerned with individual part design, but should anticipate materials and processes. These designs are captured with three-dimensional, computer-aided design (3D CAD), realistic-looking rendered images, and physical appearance models. Usually, it will take several weeks or more to narrow the best concepts down to one cohesive design direction. There will be a push and pull among the many priorities of a product: features, appearance, marketability, complexity, cost, etc. These competing priorities should converge through a series of design concept adjustments.

Good industrial design quickly begins to merge with engineering as the ideas start to become more real. Now, the general design concepts become realized as assemblies of individually designed pieces. Mechanisms and moving parts start to take a true mechanical form, and therefore determining proper materials and processes is critical at this point. Design for manufacturing (DFM) using principles such as those detailed in this book is paramount. There is no way to sidestep the effort it takes to get to realistic prototypes or useable CAD. Useful CAD and prototypes come after painstaking engineering.

If electrical systems are a product component, those features and their behavior are now also engineered as directed by the design concepts. Industrial designers, electrical engineers, and mechanical engineers should work closely together as the aspects of the design come together. The board layout, for instance, will be dependent on both the electrical requirements and the mechanical requirements such as board size, button location, and LED placement. For instance, in the case of our mustache comb, the industrial designer will have a specific idea of where the button should go so that it will be easy to use. The mechanical engineer may find it difficult to put it there because that area of the comb is too small for it to fit. But wait, the electrical engineer discovers a specialty switch out of Japan that might work. Oh, it is expensive. Furthermore, now the entire product would be dependent on this single component. What if it goes out of production next year? These are the kinds of issues that come up during the design and engineering, and often there are no clear answers.

A variety of prototypes will be an integral part of the design and engineering process. As part of the design validation you should get working prototypes into the hands of potential customers and listen to what they have to say about it. Make adjustments to be sure that your product addresses the needs of the market. These iterations are critical in delivering successful and relevant products.

Engineering design documentation includes 3D CAD, two-dimensional (2D) drawings, electrical design Gerber files, and other files that fully define all the individual parts of the product, along with a bill of materials (BOM). These files provide the necessary information to get realistic quotes from potential manufacturers.

Locating and vetting manufactures can be a full-time job by itself. Sure, internet searches can be a starting point, but your best quality match may have an unimpressive internet presence. It is best to have a manufacturer that is a specialist in similar products. If you are making an inexpensive plastic toy, you should search for manufacturers that make inexpensive plastic toys; an injection molder that is accustomed to making medical devices may not have the most efficient processes, or the right price for your application. Be ready to pay enough to partner with a manufacturer that you trust to deliver quality products. Cost should not be the main determining factor. That initially-appealing low quote can turn into frustration and more money out of pocket in the end. Finding a manufacturer for our mustache comb may prove to be a challenge. Ideally, we would want to work with a factory that makes combs. There could be some specific processes they have learned in order to get the little teeth to come out just right. However, a comb factory may have no experience packaging and waterproofing electronic components. Even simple products have an array of requirements that can quickly narrow your search, though the perfect match rarely exists.

I recommend visiting the manufacturer. Whether close to home or overseas, the cost is almost always justified. Even today, the manufacturing relationship is just that—a relationship. You must put in effort to be treated well. Let's face it; your product may not be the greatest source of revenue for your contract manufacturer (CM), so you will have to make yourself heard in other ways. You should nurture the process with your supplier from the very beginning, and from that point on—through the quoting, first article inspection, pilot production, and delivery. It helps to have an agent on-site to advocate for your interests if you are not able to be there personally. Independent production companies can provide this service that looks after quality control and timely delivery.

It takes a long time to manufacture tooling. The tooling fabrication may be done in-house at your contract manufacturer or, more likely, the manufacturer will sub-contract it out. Why does it take so long? One, to precisely manufacture tooling from large blocks of solid steel takes several time-consuming steps. First the tooling must be designed. The factory will work from the documentation of your product as a starting point. For injection molded parts they will consider gates, runners, vents, cooling systems, and mechanisms such as lifters and slides. Then they can manufacture the tooling using various machining and finishing steps. But secondly, tooling manufacturing takes a long time because your project is likely not their number one priority and you must get in line behind previous commitments. Depending on your relationship and your good fortune, it could take from a few weeks to three months to manufacture the tooling, which often represents one of the largest capital expenses of product development. It is common practice to make partial payment up front with the remainder due upon delivery.

You or your agent should be on-site for first article inspection. When the parts first come off the line you will likely need to make small adjustments to the parts for better quality, fit, and appearance. The manufacturer will also be adjusting their production parameters for better part quality. You put effort into these first (and scrapped) parts for the sake of quality and efficient production later. You and your manufacturer should be in agreement of the acceptance criteria for the parts. This can be communicated with drawings, "golden samples," and other quality documentation. Golden samples are specially designated reference parts that are used to evaluate parts off the manufacturing line.

Let's follow the mustache comb through first article inspection. We are at the factory and they have injection molded a hundred or so of each part. They look good. But when we go to put them together, there is a small gap between the cover and the comb which renders the waterproofing seal ineffective. Fortunately, the engineer had anticipated this possibility and had designed a rib that could be adjusted in a safe and predictable way. The factory engineers take the tooling and grind off .015 of an inch (.38mm) so that the rib gets just a bit thicker. (Removing material from the tool, or mold, means that material will be added to the part.) This change had been anticipated in the design as tool-safe, also called steel-safe. That is, it anticipated removal of material from the tool. It is more difficult and costly to try to add material to a tool. So, the crew runs a new batch of parts and now all the pieces fit together as planned. Well done, team.

Many products require regulatory testing for FCC (Federal Communications Commission), UL (Underwriters Laboratories, USA), and CE (Conformité Européenne) compliance. You should start this process before your product is complete and submit it to be tested early, likely at the point of the engineering build (EB), or manufacturing build (MB), which consists of the first fully-assembled, as-manufactured examples of your product. The MB units are used for product evaluation and testing. Testing can consume several months, and UL testing alone can run well over 10,000 dollars while FCC testing can come to 15,000 dollars. Regulatory testing for a small home appliance I worked on tallied up to about 25,000 dollars.

Finally, you are ready for full-scale production, assembly, packaging, and shipping. Your contract manufacturer should be able to facilitate and integrate these steps, with you also playing a supervisory role, especially for the shipping. Stick with it. You are getting closer, but here deep into the development, it starts to take increasing effort to get seemingly smaller results.

For example, say we have specified custom colors for the mustache comb: Near Black, Tortoise, and Metallic Bronze. We did the pilot production run in an unspecified generic black since that stock color is readily available in most varieties of plastic. We determined that it would not be worth it to custom-color the slightly lighter Near Black that we had wanted, so we went with a generic black instead. However, thirty-five percent of our pre-orders were for Metallic Bronze and we are not willing to lose those sales. The problem we discovered is that this particular color additive weakens the material and the teeth of the comb tend to snap off. We have several options: go with a non-metallic bronze, paint the comb after injection molding, or change the plastic material. None of these options are guaranteed. We eliminate the first option because it is not close enough to what the customers ordered, and we eliminate the second option for fear that the paint will scratch off; we are left with the third option—change materials. It turns out that the new material has a different shrink rate than the previous material, so to maintain the same size and tolerances we would have to cut new tools. This would represent an unacceptable increase in development cost and time. So, in spite of any tolerance problems it might create, we decide to shoot the new material in the existing molds. What is our risk here? Remember our effort to adjust the mold so that we would have a watertight seal for the cover? We might have to do that all over again. And we may find that the adjustment would not be tool-safe this time around since this is a change no one anticipated. These little unexpected problems can have a big influence on the time and cost to deliver your product. Take courage that you are in good company when you encounter them.

Lane Musgrave, co-founder of Reserve Strap, a battery backup watchband, reflects on this phenomenon:

> The last mile in a marathon is the most difficult. You're trying ten times as hard and achieving one-tenth the result. That's what the final ten percent of product development feels like. The only phase of Reserve Strap development when I wanted to quit was when the product was almost complete. It seems contradictory, but when you're

> in the thick of it, you don't know if/when you'll be 'done.' As soon as you solve one problem, it creates another and the endless game of whack-a-mole is the most frustrating part of design and development.

This is a time for quick and decisive decisions to resolve the issues that you can, and to dismiss the ones that you cannot. It is important to release a product that meets expectations, but many of those perfecting adjustments may be left for subsequent generations of the product.

In quickly changing industries and for products that are produced in lower quantities it can often make sense to manufacture close to home. In these instances, the shipping time from your vendor can be measured in days. For higher volume production or specialized production it is often most effective to manufacture in a worldwide manufacturing center. The shipping process from these overseas manufacturers can easily take two months altogether. Product preparation, packing, and staging at the port can take more than a week. The shipping time on the water can take about four weeks from China, for example, and it can take a week, or even much longer, to clear domestic customs. Fulfillment companies can aid in this process, and continue on from customs to their warehouses, and then to the individual customers. Or if you have your own distribution system, you would transport the product from the port to your own warehouses, and finally to the end customer.

These steps have added up to something that is starting to seem overwhelming. We'll break them down into more manageable pieces in the coming chapters, but for now, let's look to a few practical resources: Need a product design firm to get you started? Check out the design directory from Core77. Trouble with fulfillment? Outsource it to a company like Blackbox. They shipped the Exploding Kittens game of Kickstarter fame to over 200,000 backers. And there are many other choices like them. Don't know where to start with selecting a manufacturer? Use a service like Eastbridge Engineering. They will quote and vet several well-matched choices. Already drowning with the engineering of your project? Check out hardware product accelerators like the Flex Invention Lab. See the RESOURCES section at the end of this book for more information on these and many other services. You can also check out brightpd.com/resources for an updated and expanded resource list.

For a sample project schedule that includes the principles of this chapter, look toward the end of the book to APPENDIX I. This project schedule follows a typical development process with parallel paths for independent items and long lead-time items in order to compress the time to delivery. As evident from its interconnected nature, late completion of any individual step can lead to late fulfillment of the product.

In the next chapter we will take a closer look at the first item on the timeline: design and engineering. Inevitably, the design of a product will need to be suited for particular manufacturing processes. And the most suitable processes are closely tied to production volume. So, we introduce design for manufacturing (DFM): a balancing act between market requirements, features, and appearance, all countered with the cold reality of established fabrication processes and minimum production volume.