

Appendix J

Best Practices for Training Startups to work with Manufacturers

This guide is intended to help young companies understand how to work best with manufacturers, vendors and suppliers. It provides best practices on how to work with manufacturers and also some general information on common manufacturing processes. This guide is intended to be used as a reference and a resource for young hardware companies, and provide an outline and checklist for companies as they engage in product development.

Before engaging with any manufacturer, ask yourself the following questions:

- Do I need a custom part or can I use an off-the shelf piece?
 - Just because you have a new product does not mean it has to be made of entirely new pieces. Off the shelf components can be cheaper and faster.
- What process do I want to use? Why?
 - Do you know what process you want to use? Have you seen the machines you think will be making your product? No matter, make sure you visit any manufacturer you consider entering into a contract with.
- Do I have an assembly process?
 - Assembly helps guide the product development so make sure you have an idea of how the final product will come together BUT be open to hearing what your manufacturing partners suggest as well.
- Have I identified my customer to determine needs & uses of my product?
 - Do your customers have specific needs? Does your product need to be made of specific materials based on use? Knowing this will help inform your conversation with a manufacturing partner and develop your product faster.

After addressing these issues with your team, you are ready to talk to manufacturers.

General Best Practices in Establishing a Relationship with a Manufacturer

Be prepared to meet with Manufacturers

- People will be more likely to believe in you if they meet you in person.
- Bring pictures and examples or previous models of your work.
- Make sure when you visit a manufacturer you evaluate them on the following items:
 - cleanliness
 - space
 - tracking management system (ERP)

- The earlier you can meet with manufacturers in your design process, the higher your likelihood for finding a partner who can help you grow faster and better.

Before you meet with a Manufacturer, make sure you are prepared for the following:

- Check a company's &/or vendors credit - they are checking yours & it is standard practice.
- Always ask a manufacturer you are contracting with how they manage IP's & don't be afraid to ask for an NDA. (Generally, electronics tend to require less engineering than other processes & IP concerns are less important in this area.)
- Make sure you know what is important to the manufacturer, e.g. making money, having a good relationship with a startup, and getting a potential long term customer. Also you need to know what is most important to you - good service, quality parts, on time delivery, someone to help you manage the whole process, etc. Identifying these needs will help you refine your pitch and help you find the best partners.
- Make sure have an internal process for revision controls - OR - if you don't have one, ask your manufacturers what process they use so you can make sure you are compliant. Revision controls are important so that manufacturers do not receive different versions from different people. Before you submit anything to a manufacturer - check your revision level.
 - One way to do ensure revisions are accurate and up to date is to list ECO processes (ECO = Engineering Change Orders) throughout the design. Make sure throughout the design the bottom of the part matches with the top, and put revision level on the model.

What information to Share with a Manufacturer and When

- Tell people what you are building - if a manufacturer or engineer has an understanding of your whole product, they may be able to flag issues, or make helpful suggestions to your design ahead of time. This also gives them an opportunity to become personally invested in your project - which can lead to a better & more productive working relationship.
- It is helpful for manufacturers to know where the piece they are building is going next - and/or what it is fitting into. This can change how the piece is delivered (pallet size, less packaging, different shipping array) which can reduce overall costs for you. Importantly, it can improve delivery time, overall efficiency, and help them assist you with your final product.
- Many manufacturers can manage the full supply chain of your product - but this often requires volume and it is good to ask up front what services your manufacturer provides. Doing it all with one company can be more efficient and result in a better product.

- Pitch your manufacturer. Be prepared to do this when you go and meet with them for the first time. Make sure you know what they want and how you can help them get there (see above). You can find this out by researching other customers they have, what industries they work in (or express interest in working in), and what questions they ask you ahead of time.

Make sure you know the following answers & can ask a manufacturer about each before you meet

Even if you don't have all the answers, you should show that you have thought about these questions. And if you don't have answers - be prepared to explain why you are speaking to a manufacturer at that time. Finding manufacturers whom you can speak with and visit easily allows you to learn about how your product is made and make adjustments as necessary, which can be invaluable as you develop prototypes, beta-runs, pilots and first orders.

- Timing - when do you need your order?
- Volume - how many do you need? More is usually cheaper
- Fulfillment - Do you need your manufacturer to send finished products to final customer?
- If your manufacturer can't complete the whole job will they contract out for you? How will this work? Get details.
- Can this manufacturer help with commercialization?
 - What is their filing & revision system for files? Make sure you adhere!

General Best Practices: Electronics 101

#1 problem for electronics manufacturers is customers buying their own parts - make sure you have a conversation with your contract manufacturer about the parts you are ordering.

- Consider using OctoPart - common parts library

Make yourself aware of the parts your manufacturer uses and make sure if you are ordering your own pieces that you check with your manufacturer first to make sure you are ordering pieces they can work with.

Package-on-package (PoP) is mounting 2 circuit packages on top of each other and is very expensive. You should ask if your contract manufacturer can do this process for prototypes as this is not always available.

The Pitch is the center of 1 dimension to another (.3mm about cutting edge). This is important to know so you can confirm that all parts are in their correct places.

Make sure not to overlook the thickness and materials and color of the circuit board you are using - this impacts design & cost.

- Aluminum boards are more expensive than other options.
- Stainless steel is 3times as expensive as aluminum.

BGA = a Ball Grid Array - is more expensive than other arrays because all the solder is under plastic.

Wire harnesses are done by hand which can affect timing on order.

Pin & Paste is cheaper than hand soldering a board.

Be prepared to spend a minimum \$500 - \$1000 for Surface Mounted Technologies (SMT)

Conformal coating is very expensive.

Make sure you know when the Chinese New Year is if you order any parts from China because factories shut down during the holiday and things will take longer. It usually falls in late January or early to mid-February.

What to ask & have ready for your Electronics Manufacturer before you sign a contract

- Timing
- Volume
- Wire harnesses - do you need them?
- Box build - do you need the board encased in anything? If yes do you want your board contractor to do both? Does the contractor you are speaking to offer this service?
- Purchasing & Fulfillment - Do you need your manufacturer to send finished products to final customer? Do you need the manufacturer to order your pieces for you?
- Do you need a label?
- Does board need to connect to any hardware? Do you need to hire someone to do this or can your manufacturer?
- Check company cleanliness, look for flugs, an acid that can accumulate on boards.
 - This is why it is important to visit a place before or while you are negotiating to see the cleanliness & general environment of a manufacturer.
- What is the company filing & revision system for files? Make sure you adhere!

5 things you need for a PCB order

- 1) BOM = Bill of Materials - NO PDF's (PDF's are harder to copy and take pieces out of)
- 2) Gerber data & board details (sign NDA for this)- silkscreen, copper weight, materials, board materials, board color
- 3) XY data (centroid data)
- 4) Quantity
- 5) When you need them (It takes 20 days for delivery on avg.)

General Best Practices: Sheetmetal Fabrication 101

Extrusion can help reduce costs.

Using a laser cutter is better for fast jobs but a laser can't be used to cut reflective materials.

- e.g. You cannot laser copper.

When determining what type of manufacturing process to use - make sure you know the thickness of the materials you plan to use and whether or not it will work with your planned design.

- You cannot cut a hole smaller than the thickness of material

What to have ready for your Sheet Metal Fabricator before you sign a contract

Make sure you have the following ready to send to the manufacturer:

- sent solid assembly
- solid part files
- drawing file
 - Make sure your parts have a "+" & "-" on each side. This is necessary so quality controllers and engineers can inspect your design
- Do you know your tolerances? If you do - share them and how you got them. If you don't say that.

Make sure you know the following answers & can ask the manufacturer about each:

- Timing
- Volume
- Fulfillment - Do you need your manufacturer to send finished products to final customer?
- If your manufacturer can't complete the whole job will they contract out for you? How will this work? Get details.
- What is their filing and revision system for files? Make sure you adhere!

Background information on Plastics & Extrusion

When working in plastics & forming - materials will almost always be a major cost. #1 cost is usually the mold. Make sure your mold is accurate because it can take a long time to change or adjust a mold.

Once you are ready to make a mold, ask if you can do a trial with the company. Generally, the manufacturer pays for the trial and then will own everything associated with the trial, but it is a cheaper way to get molds made.

3D printing is useful for prototyping if you have extruded parts but in the long run, extrusion is likely cheaper. Extruding is also ideal for cylindrical shaped products and can provide an excellent surface finish.

Vacuum or thermoforming is good for small unit orders and is usually cheaper than injection molding.

- Injection molding becomes cheaper when you have orders for 10,000 units or more.
- Injection molding also reduces materials costs.

What to have ready for your Plastics Manufacturer before you sign a contract

Make sure you have drawing files ready to send to the manufacturer.

Make sure you know the following answers & can ask the manufacturer about each

- Timing
- Volume

- Fulfillment - Do you need your manufacturer to send finished products to final customer?
- If you want to try a mold but don't think it makes sense based on volume/cost, will they engage in a trial with you?
- Can this manufacturer help with commercialization?
- Does your product require any special compounding? If so what and why?

This document is intended to act as a guide for young companies who are new to manufacturing processes and dealing with manufacturers. The questions and information contained within this guide have been compiled from conversations and recommendations from manufacturing experts. Most importantly, startups and young companies should seek out manufacturers early in their product development, find manufacturing partners who are willing to answer questions and who are nearby so visits and face-to-face conversations can take place often.

If you have any questions about this or any other issue relative to manufacturing please contact Micaelah Morrill, Program Manager - Manufacturing Initiative, Greentown Labs - mmorrill@greentownlabs.com / 617.843.5159.

MANUFACTURING GLOSSARY

BGA = A ball grid array - a type of surface-mount packaging (a chip carrier) used for integrated circuits. BGA packages are used to permanently mount devices such as microprocessors. A BGA can provide more interconnection pins than can be put on a dual in-line or flat package. Often more expensive than other arrays because all the solder is under plastic.

BOM = Bill of materials - The list of parts or items that make up a product assembly. A complete product BOM often includes subassemblies, which may represent different steps in the assembly process. For instance, a lawn mower may include the following elements: a handle assembly, a metal deck assembly, a control assembly, a motor and a blade assembly. (IKEA)

- **BOM Level** = Bill of materials level -The place occupied by a part or assembly in the hierarchy of a BOM.

- **EBOM** = Engineering bill of materials - A BOM organized according to CAD/EDA tool and engineers' preferences and processes. The EBOM represents only the physical product being "engineered," not the packaging or manufacturing consumables. It often includes items for a single engineering discipline only, summarizing or excluding items from other disciplines.

Bread Box = an area for storing electronics parts.

CNC = Computer Numerical Control - CNC Machining is a process used in the manufacturing sector that involves the use of computers to control machine tools. This means a computer converts the design produced by Computer Aided Design software (CAD), into numbers. Tools that can be controlled in this manner include lathes, mills, routers and grinders.

Compounding - when a solid or liquid standard material creates a new substance that is then molded and formed to customized to customer needs. Often used in plastics.

Deburring = a finishing method used in industrial settings and manufacturing environments. Metal is frequently machined using many processes in order to create pieces of specific shape and size, and it may be welded, molded, cast, trimmed, slit or sheared. These procedures often create ragged edges or protrusions. The raised particles and shavings that appear when metal blanks are machined are referred to as burrs, and the process by which they are removed is known as deburring.

DFM = Design for Manufacturability

EMI = Electromagnetic Interference - (also called radio-frequency interference or RFI when in radio frequency) is disturbance that affects an electrical circuit due to either electromagnetic induction or electromagnetic radiation emitted from an external source.

ERP = Enterprise resource planning (ERP) - is business management software—usually a suite of integrated applications—that a company can use to collect, store, manage and interpret data from many business activities, including: Product planning, cost. Manufacturing or service delivery. Marketing and sales. Inventory management.

Extrusion = a process used to create objects by pushing a material through a die. The two main advantages of this process over other manufacturing processes are its ability to create very complex cross-sections, and to work materials that are brittle, because the material only encounters compressive and shear stresses.

FAIR/1st Article = First Article Inspection Report - a formal method of providing a measurement report for a given manufacturing process. The method consists of measuring the properties and geometry of an initial sample item against given specifications, for example a drawing. Items to be checked in a FAIR are wide and varied and may include distances between edges, positions of holes, diameters and shapes of holes, weight, density, stiffness, color, reflectance or surface finish. Despite the name, the inspected article may not necessarily be the 'first' produced. First article inspection is typically called for in a contract between the producer and buyer of some manufactured article, to ensure that the production process reliably produces what is intended.

Fiducials = Fiducial Marks are precision targets built into a PCB surface which are used by a pick and place machine to fine tune it's placement accuracy & act as reference points for a machine. *Make sure that you have your fiducials in the right place*

Grinding Machine, "Grinder" = is any of various power tools or machine tools used for grinding, which is a type of machining using an abrasive wheel as the cutting tool. Each grain of abrasive on the wheel's surface cuts a small chip from the workpiece via shear deformation.

HBM = Horizontal Boring Mill

HS = The Harmonized Commodity Description and Coding System, also known as the Harmonized System (HS) of tariff nomenclature is an internationally standardized system of names and numbers to classify traded products.

Lathe - Machine that rotates the part against a stationary cutting tool. (check this)

Mill - Machine that rotates the cutting tool against a stationary part. (check this)

(The orientation of the various components is a variable, not a fixed value. On a lathe the chuck sits horizontally and the tool post is vertical. On an HBM, the tooling rotates horizontally, instead of vertically)

NPI = New Product Introduction

NRE = NRE (non recurring expenses) associated with a manufacturing facility production ready for a customer. These are costs that are normally passed on to a customer.

OEM = Original equipment manufacturer - is a term used when one company makes a part or subsystem that is used in another company's end product.

PCB = Printed Circuit Board

QFN = Quad Flat No Leads - is a more expensive board option because it is a device with no solderable areas

SMD = Surface-Mount Device (SMD) - created with SMT (See below) In the industry it has largely replaced the through-hole technology construction method of fitting components with wire leads into holes in the circuit board. Both technologies can be used on the same board for components not suited to surface mounting such as large transformers and heat-sinked power semiconductors.

SME = Small to Medium Enterprise, often refers to manufacturers who employ less than 100 people and who create products or components for other companies.

SMT = Surface-Mount Technology - a method for producing electronic circuits in which the components are mounted or placed directly onto the surface of PCBs.