Hardware Development 101

Cheatsheet

The Sparrows

Hello! Welcome!

Hello! Thank you so much for downloading our Hardware Development Checklist!

In this document, the team at The Sparrows has distilled some key insights from their combined decades of working on hardware development in Shenzhen, China.

Hardware development is a monster of an undertaking for many reasons, but the key challenge is **accounting for and addressing the unknown unknowns** — for all the due diligence and planning one may put into their product development, things always find a way to absolutely *explode*.

So at best, we hope this guide can be a useful blueprint to help you check boxes and bring your hardware product to market. At worst, we hope you get a laugh from the *real life* pain documented in the following slides.

Cheers, and welcome!

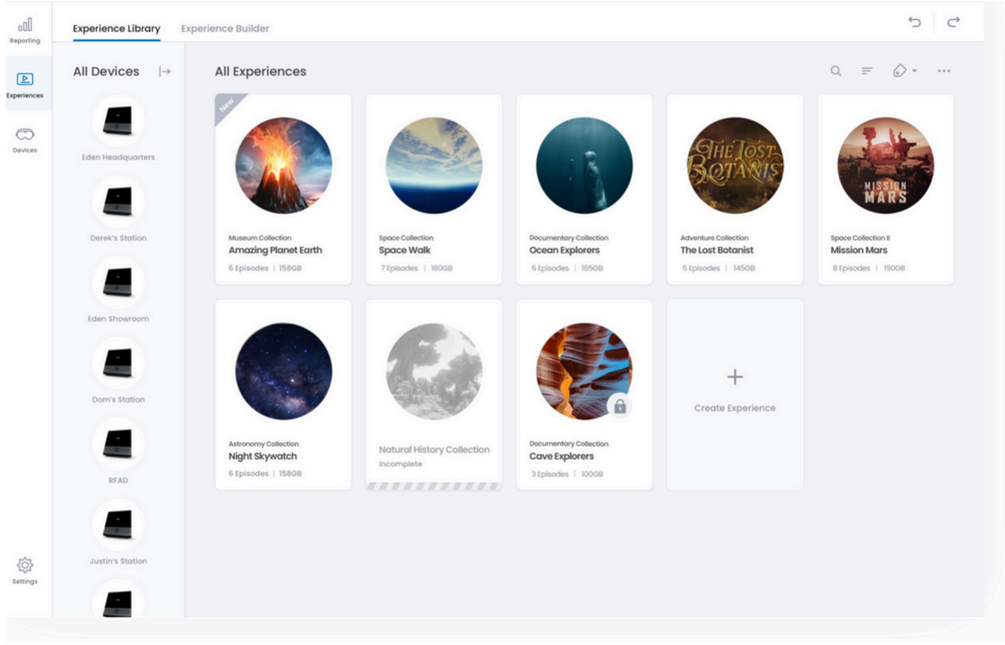
-Josh @ The Sparrows

Intro to VR System

For the purpose of this guide, we will reference our actual experience developing a commercial VR headset system.

Headset
+ Removable Handle
+Charging Stand

Touchscreen Tablet



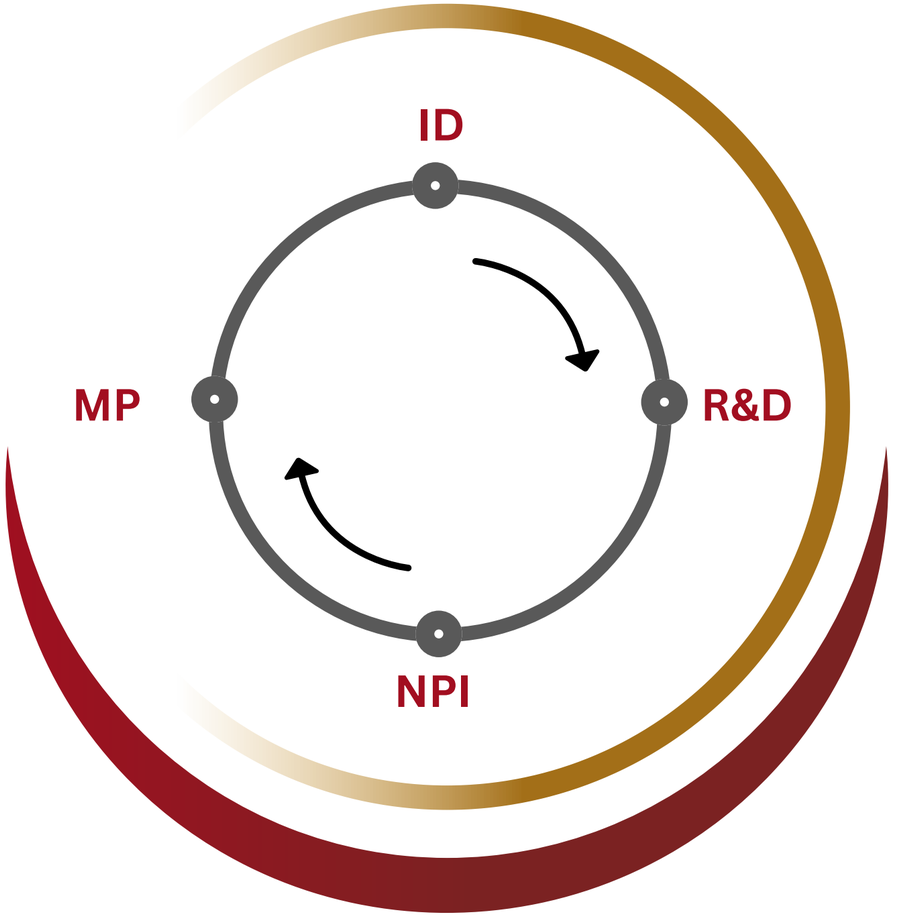
Software Backend for Content and Fleet Management

Hardware Development Roadmap

Generally speaking, engineers and designers will split up the product hardware design phase into four key steps, that should proceed in a fixed order:

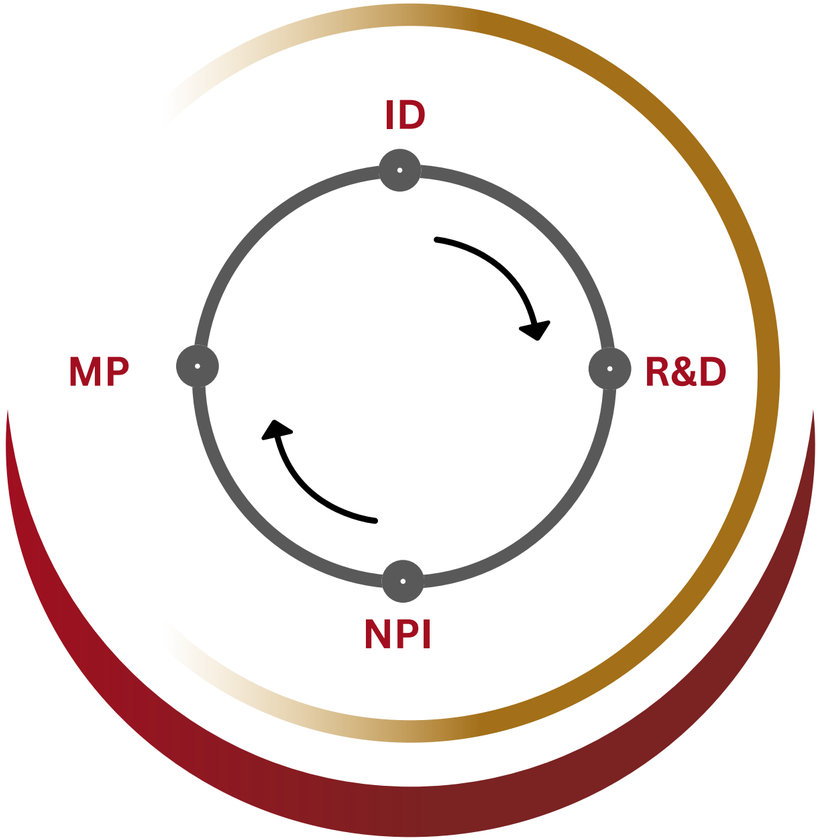
1. Ideation and Industrial Design (ID)
2. Research and Development (R&D)
3. New Product Introduction (NPI)
4. Mass Production (MP)

This cycle generally does proceed in a fixed order from phase to phase... generally. Mixing happens often, TBH. But whatever you do, **please completely finish ID phase before proceeding with anything else!**



Hardware Development Roadmap

Here, we define the rough “target” for each of these phases:



- **1. ID/Ideation**
  - Product Concept Definition, Functional Requirements
- **2. Research and Development (R&D)**
  - Functional Prototypes, Visual Prototypes, “Golden Samples”
- **3. New Product Introduction (NPI)**
  - Production Process Stability, Supply Chain Lock & Certifications
- **4. Mass Production**
  - Selling Product, Doing Periodic Checks for Process/Supply Stability

Ideation

*Define **everything**, align on product direction... and remember the 12 P's*

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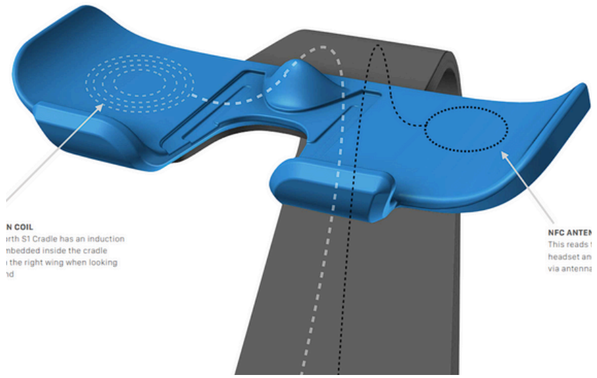
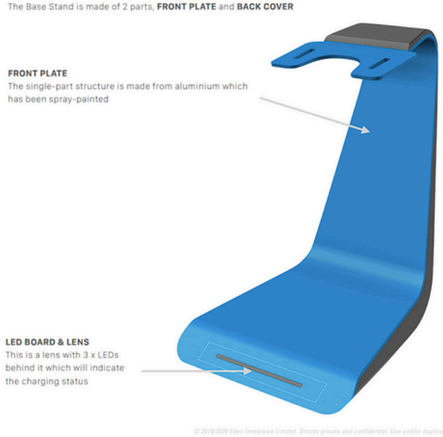
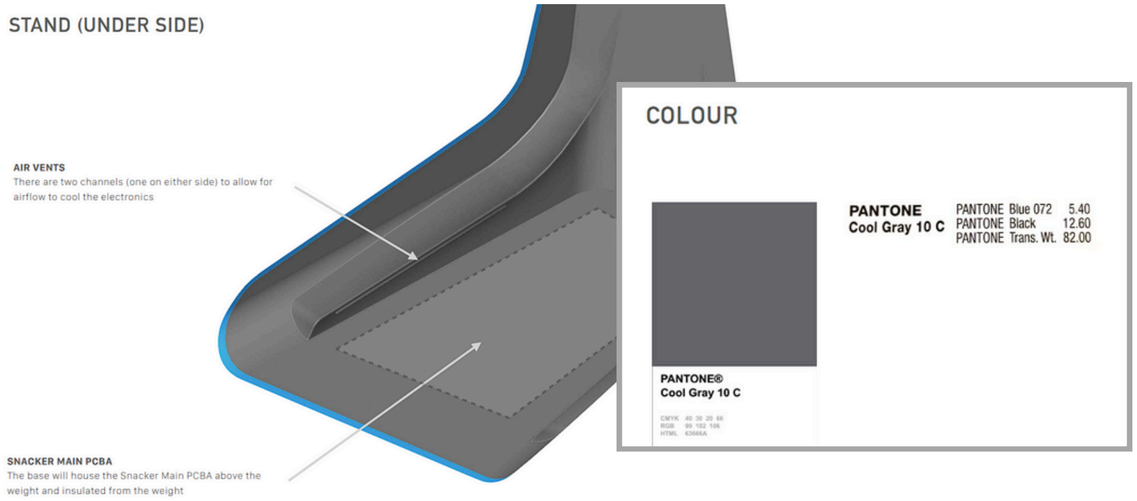
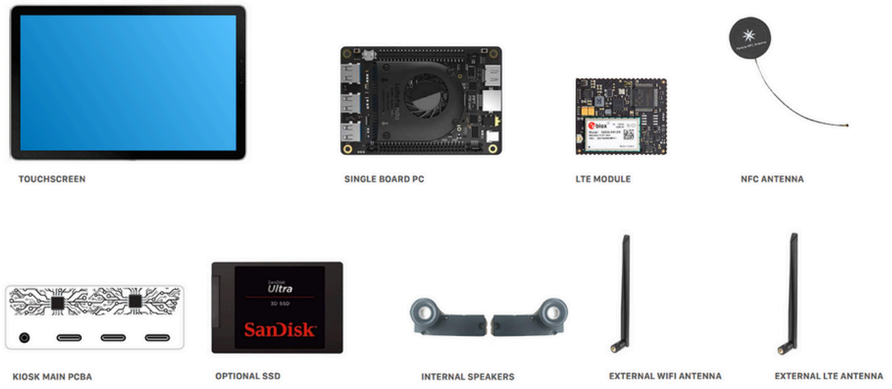
Product Requirements Document









GENERAL:
Ideal board is the **LattePanda DELTA 432** or similar spec board

CPU	Intel 8th Gen Celeron Processor N4100
CORE	1.1-2.4GHz Quad-Core, Four-Thread
GRAPHICS	Intel UHD Graphics 600, 200-700MHz
RAM	4G LPDDR4 2400MHz
MEMORY	32GB eMMC V5.01
EXT MEMORY	x M.2 M Key, PCIe 2x, Supports NVMe and PCIe SSD
WiFi	WIFI 802.11 AC, 2.4G & 5G
BLUETOOTH	Dual Band Bluetooth 5.0
ETHERNET	Gigabit Ethernet
OS CAPABILITY	Linux Ubuntu
USB	3x USB 3.0 Type A and 1x USB Type C, supports PD, DP, USB 3.0
DISPLAY OUT	HDMI, Type-C DP, eDP Touch Display
POWER SOURCE	12 volts 2A input from JST PH2.0 connector or Type-C 45W
EXTRA COMPONENTS	Expandable SD card slot
DIMENSIONS	L 130mm x W 90mm x H 14mm
AUDIO OUT	3-pin audio Mini Jack
ANTENNA	I-PEX connector for external WiFi antenna

This is an incredible example of a PRD (product requirements document), detailing the customer's required form, mechanical/hardware function, and CMF (color, material, finish)

Ideation Cheatsheet

Goal

Fully define your product's aesthetics, specifications, critical performance metrics, target market, and target economics

Deliverables

- Initial Budget
- PRD
- BOM for Critical Components
- Rough Timeline to Market
- Product ID & CMF

Critical

- Be Meticulous!
- Add Buffer when Possible
- Use Online Resources to estimate Project Costs
- Early Assessment of Product Mfg. Requirements based on ID

Risks

- Poorly defined PRD
- Poor team alignment on project direction
- Designs not physically feasible, or economically out-of-scope
- Poor timeline design

DRIs

Product Designers, Industrial Designers, UX Designers

PRD: Product Requirements Document
BOM: Bill of Materials
ID: Industrial Design
Mfg: Manufacturing

Research & Development

Marathon, not a sprint! Or maybe a triathlon...

Known knowns, Known unknowns, and unknown unknowns...

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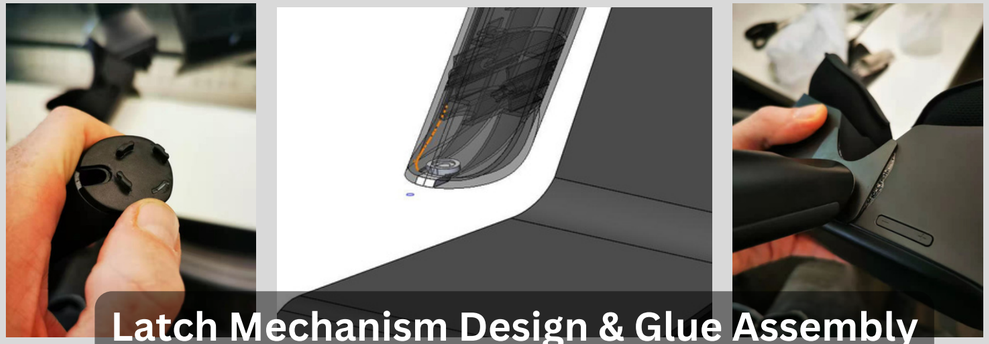
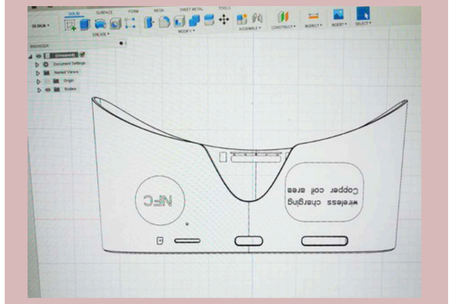
VR Headset R&D

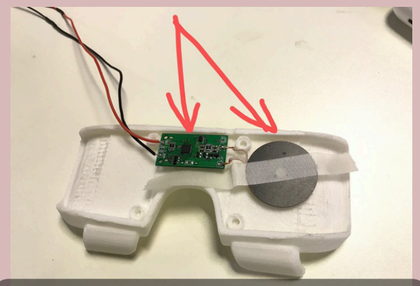


Latch Mechanism Design & Glue Assembly



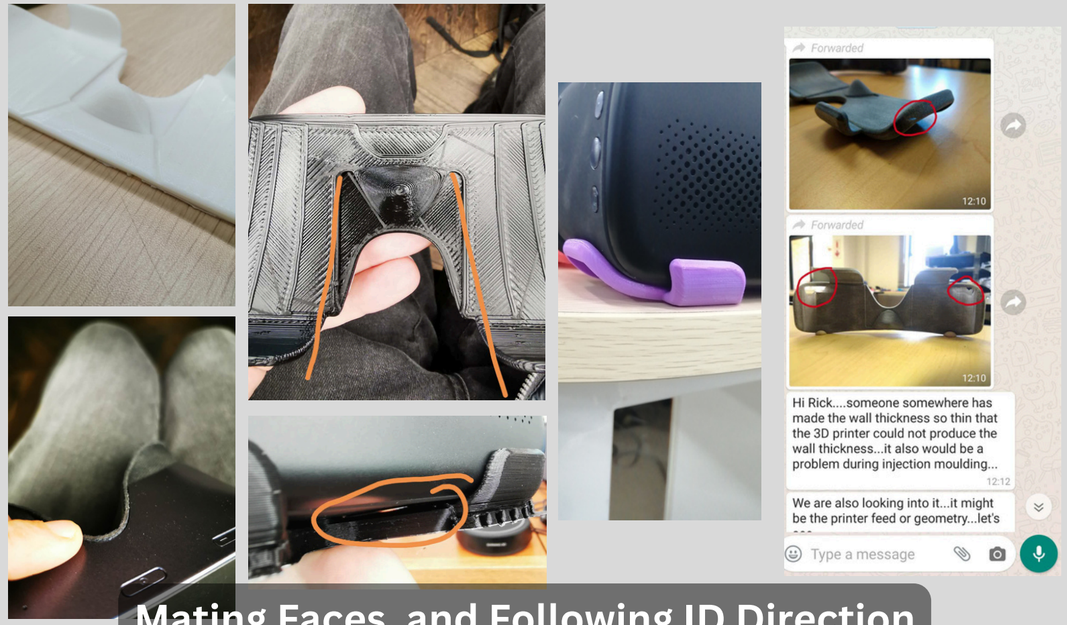
2nd Derivative Continuous Curvatures

Kensington Lock Integration



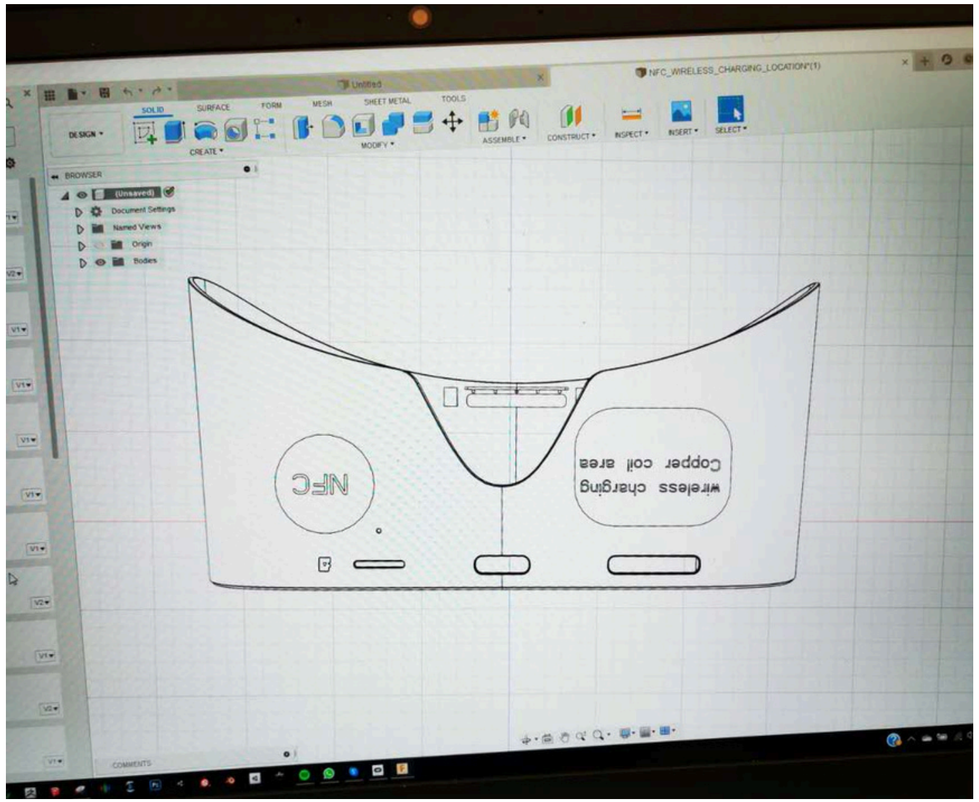
Internal Architecture

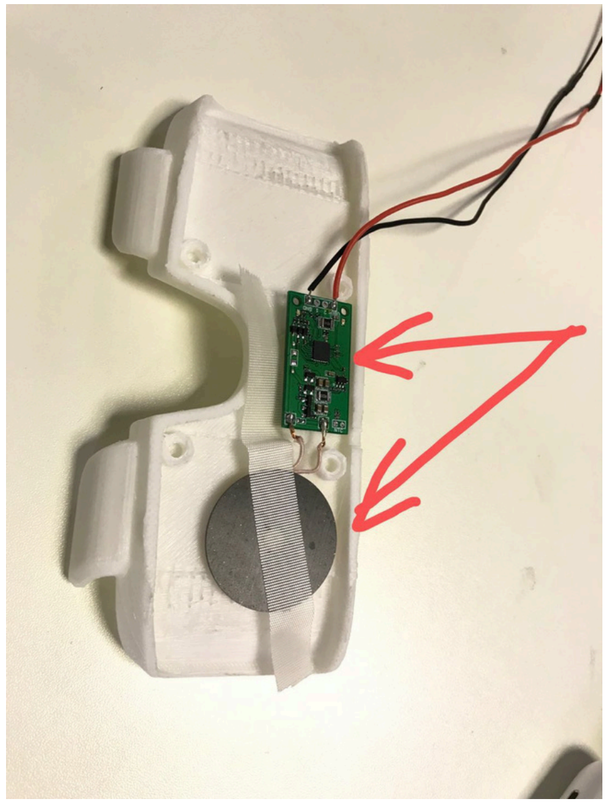
Headset Manufacturer Collaboration and QC



Mating Faces, and Following ID Direction

VR Charging Stand Architecture





While designing the VR headset charging stand, we struggled to balance the space constraints of the industrial design with the internal electronic components

The Tip of the R&D Iceberg…

Headset Charger

- Wifi Antenna Integration
- Wireless Charging Coil Overheating
- PCBA Count Reduction
- Finding IC for USB-C Data/Power IO Port
- External Metal Plate Dev.
- Handle DFM Issues
- Stand DFM Issues
- NFC Alignment w/ VR Headset
- LED Diffuser Snap-in Assembly and Flush w/ External Piece
- DFA

Touch Screen Panel

- 4G/Wifi Antenna, Power Button Downselect
- Backup Power Integration
- Touchscreen Development (Model selection, silk screen glass placed on top, Fixtures, Surface Finishing, display eDP cable integration with LattePanda)
- Alum. Plate Bending and CMF Optimization
- Speaker Grill Development (anti dust filter, optimizing for smallest grille hole size, speaker replacement)
- Space for Camera Integrations
- Linux Flashing onto SBC

VR Headset

- Incorrect Black Surface Coating
- Coldshoe Glue Overflow
- Nose Space Differences b/t Asia and Europe Versions
- NFT Integration
- Eye Pillow Material Optimization
- Covid-proof Cover for VR Headset
  - Alcohol Friendly Surface Finishes
- Android OS Integration
- 90 deg. USB Cable Selection

Accessories

- USB-C Cables CMF & Packaging Downselect
- Cleaning Cloth and Spray Bottle Downselect
- Packaging Design, and Protective EVA Foam Sourcing

DFM: design for manufacturing
SBC: single board computer
DFA: design for assembly
PCBA: a PCB with components assembled on it

R&D Cheatsheet

Goal

Create cosmetic & functional models of product, define internal architecture & assembly, identify key failure modes, create ‘golden samples’

Deliverables

- EE and HW BOM
- Completed CAD
- Golden Samples
- FMEA
- DFM and DFA feedback
- Factory (Inj. Molding, Metal, PCB) Bulk Manufacturing Quotations
- Packaging Design Drafts

Critical

- Fail and iterate often
- Work in parallel
- Understand limitations and cost of prototype vendors
- Packaging is important
- Scope for future mold costs and amortize

Risks

- Jumping into trial run without fully qualifying failure modes and production best practices
- Budget overruns from delayed R&D phases
  - high complexity
- Scope Creep

DRIs

PM, MechE, EEs, FW Eng., SW/UI/UX Programmers, Packaging Engineers, Prototype Assembly Factories

DFM: design for manufacturing
FMEA: failure mode and effects analysis
DFA: design for assembly

New Product Introduction

Marathon, not a sprint! Or maybe a triathlon...

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After your “golden sample,” work continues!

3.2 Test Procedure

The test has been conducted according to following test setup:

- Height: 76.2cm
- Drop contact surface: marble floor
- Drop point: 1 corner, 3 edges, 6 faces
  - The corner should be the weakness corner of the package
  - The 3 edges are the 3 edges extended from the weakness corner

Figure 3-1. Weakness corner and edges

- One time drop per each face, edge, and corner. 10 times in total.
- Cosmetic inspection and basic function check before and after Drop test
- Refer to the Table 3-1, the height of drop has been defined by ISTA according to the sample's weight. The drop test is implemented with 76.2cm according to the box's weight (4.64kg)

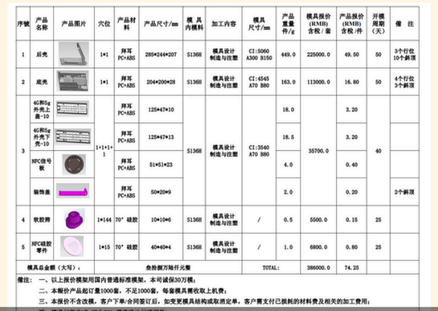
Table 3-1: Reference between Sample's Weight and Height of Drop (ISTA)

Weight(pounds)	Weight (kg)	Height (inch)	Height (cm)
1~20.99	0.454~9.53	30	76.20
21~40.99	9.526~18.893	24	60.96
41~60.99	18.597~2[illegible]	15	48.26
61~70	27.67~31.75	12	30.48

Prepare (and droptest) Packaging

OEMs for Custom Label Accessories

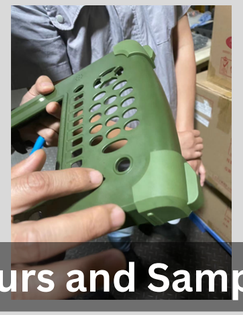
Lockdown Supply Chain



Get Manufacturer Quotes & DFM

Production Line Audits and Reviews

Trademarking & NNN Agreements



Factory Tours and Samples

Assembly Instructions

Certification Testing

Trial Run

NPI Cheatsheet

Goal

Secure all license, certificates, and legal documents; develop healthy relationship with manufacturers; lock machine parameters and define QC standards

Deliverables

- Product Certs.
- Product Trademarks
- Mass Mfg. QC Req.
- IQC/FAI/OQC/IPQC Standards
- Mfg. Contracts (w/ legal review)
- NNN/NDA Agreements
- ESG Definitions
- Sales/Distribution Plan

Critical

- Be well-versed in required certificates
- Ensure product is legally protected globally
- Understand your supply chain & plan for backups
- Familiarize yourself with local customs

Risks

- Certificate rejections can be extremely costly
- Supply chain shocks can always happen
- If you don't own IP in that country, it's not "your" product

DRIs

Test Laboratories, QC/System/Process Engineers, Lawyers, ESG/Certification Consultants, Supply Chain Managers and Vendors

IQC/OQC: Incoming/Outgoing Quality Control; FAI: First Article Inspection; IPQC: Incoming Process Quality Control; ESG: Environment, Safety, and Governance

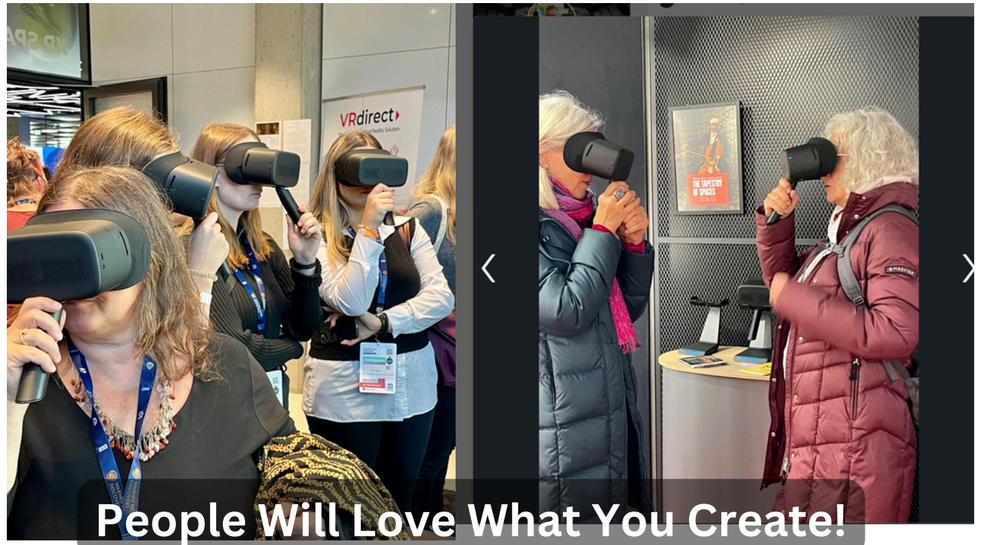
Mass Production

The Finish Line


Ensure Checks for Stable Production!


Keep Your Yields High!

Organize Warehousing & Logistics



People Will Love What You Create!

MP Cheatsheet

Goal

To produce your product with high precision, high efficiency, and in a cost effective manner. To control for quality deviations as the result of manufacturers, materials, or supply chain.

Deliverables

- Your product, over and over again

Critical

- Custom SKUs or designs should be done and locked
- Post processing and waste reduction plan, ESG compliance
- Scalable according to individual need

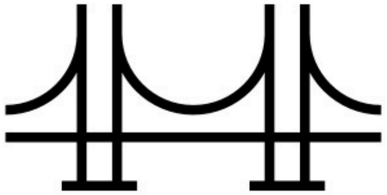
Risks

- Inflexible to customer demand or design changes
- Capital intensive initialization
- Low yield / poor QC leading to high return rate
- Supply Chain blocked

DRIs

Automation Eng., Quality Control Eng., Supply Chain Managers, Logistics Companies, Manufacturers, Assemblers

If you need any help, reach out!



Build Bridges

Connecting you to dozens of China-based technical resources

Gain Clarity

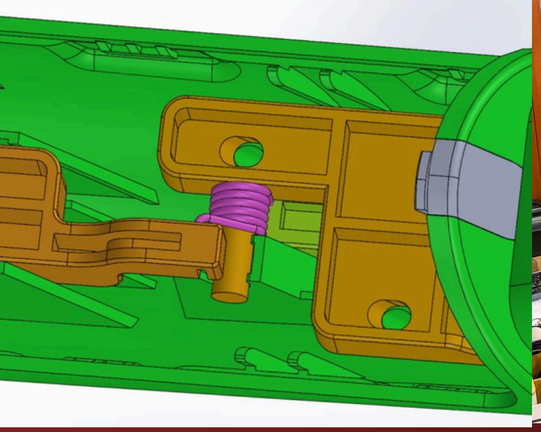
Managing full supply chain, providing visibility and control

Monitor Progress

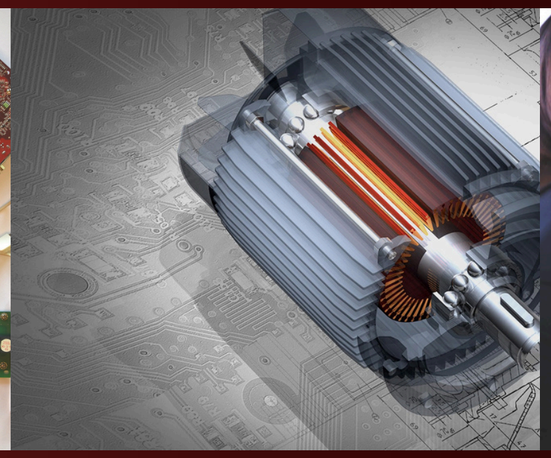
On-site audits and inspections to ensure development success

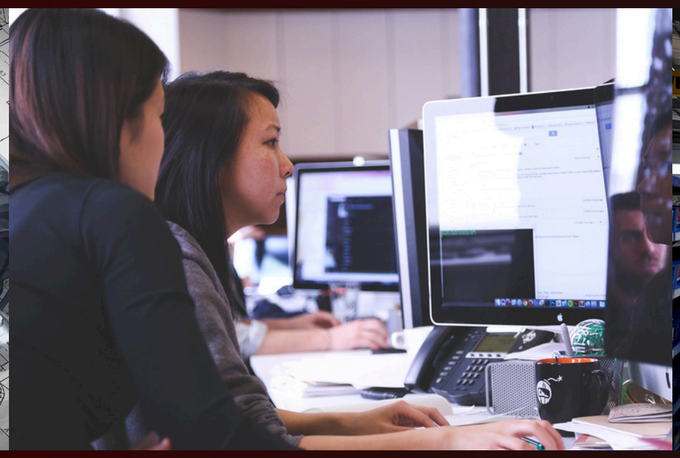
Streamline Success

Integrating quality control processes for repeatable production



The Sparrows will tackle your hardware production challenges so that you can focus on your business.





THE SPARROWS

Our team is diverse, qualifed, and experienced

Josh Woodard, **Partner**
MechE@MIT
Schwarzman@Tsinghua
PM@Apple

Susan Su, **Partner**
MechE@MIT
K. Lisa Yang Center for Bionics

Sadie Cui, **Supply Chain**
10+ Yrs. in Supply Chain and Mfg. Mgmt
PMP Certified

Richard Zhang, **Law**
Legal & IP Advisor to AmCham South China
GTL Law Firm

Dawn Wendell, **Advisor**
MechE@MIT
MechE(MS,Ph.D)@MIT
PM@The AI Institute

Matthew S Cain, **Advisor**
CogSci@MIT
Psych(Ph.D)@Berkeley
VR/AR@US Army CCDC

Recent Client Engagements

AI-powered Speech Toy

Sourcing & Hardware Development

India

NGO Health Diagnostics Tool

Sourcing & Hardware Development

USA

Portable Charging Solutions

Sourcing & Hardware Development

UK

Hygiene Products for Women

Manufacturing & Brand Development

Sierra Leone

Countertop Sprout Grower

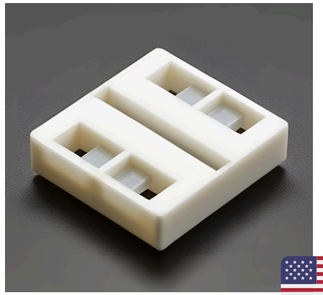
Quality Control & Process Development

Canada

Stainless Steel Engraved Pens

Manufacturing & Sourcing

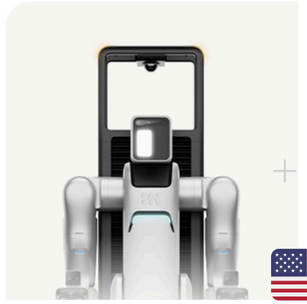
USA



Microfluidics Testing Kit

Sourcing & Hardware Development

USA



Remote Controlled Humanoid Robots

Sourcing & Market Research

USA

AC Dehumidifier Filter

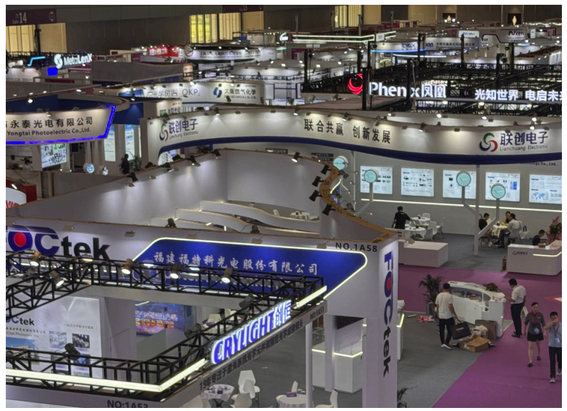
Sourcing & Project Management

USA

Highlighted Projects

NGO Health Diagnostics Tool

Oct. 2024 — **Nov. 2024** — **Jan. 2025** — **Feb. 2025**



ODM identification and selection for custom PCB hardware and firmware development

Manufacturing tour for NGO group, arranging hotel, transport; visits to 5 ODMs & 2 trade shows

Project management for PCB and firmware development, negotiating agreements and arranging samples

Development & production quotations for firmware and critical modules at qtys. of 1k, 10k, and 100k

Testimonials

Avatar Robotics

It’s been absolutely amazing working with the Sparrows. Their incredibly smart team became our **command center on the ground in China.** They quickly scouted manufacturers and met with target robot suppliers, and found additional suppliers and products we didn’t even known were available. **The Sparrows found opportunities for us to reduce our BOM [cost] by 50%** while still maintaining quality, which ultimately could **save us hundreds of millions in the long term**.

- Colin Webb

Let’s talk soon!

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