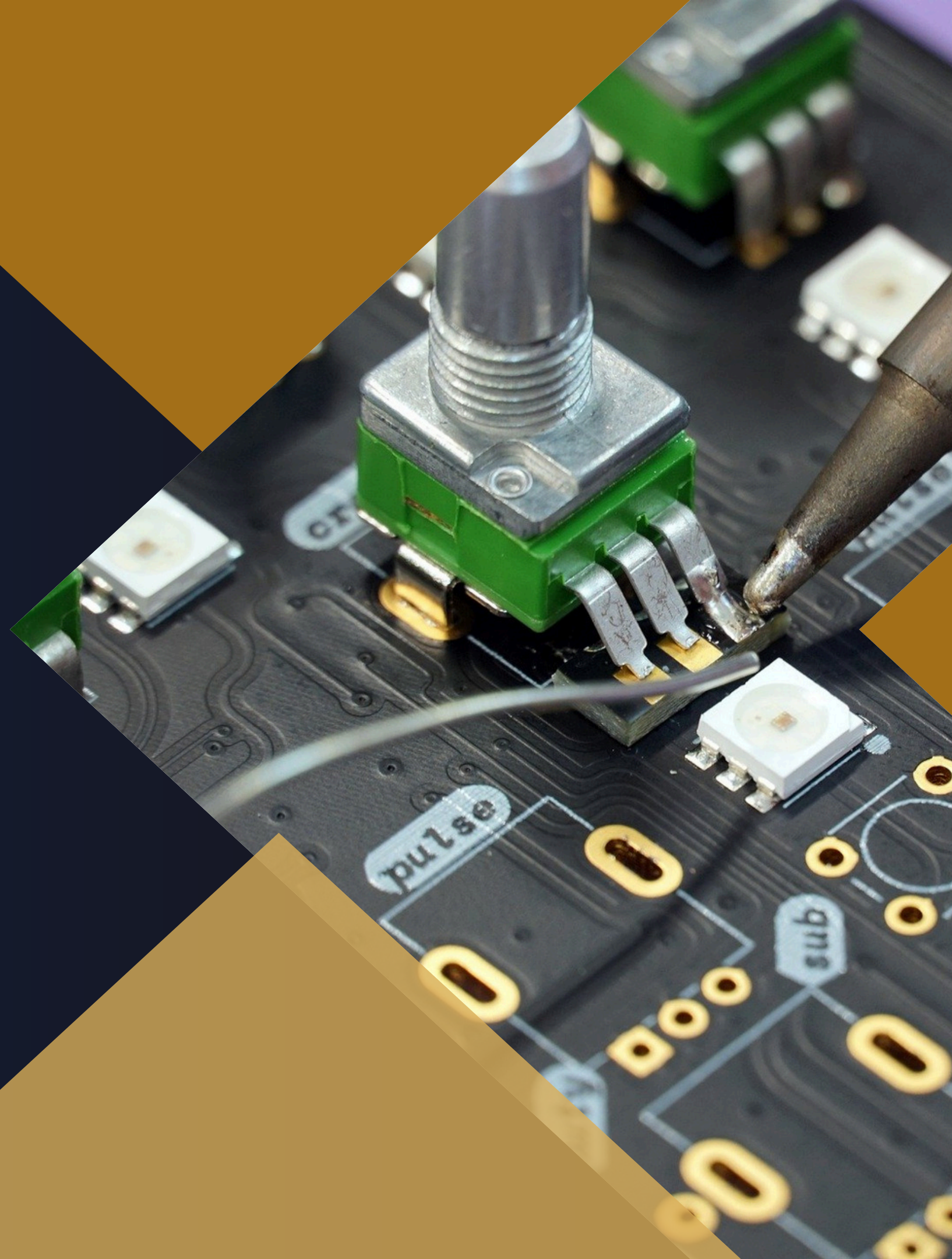


Hardware Development 101

Cheatsheet



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



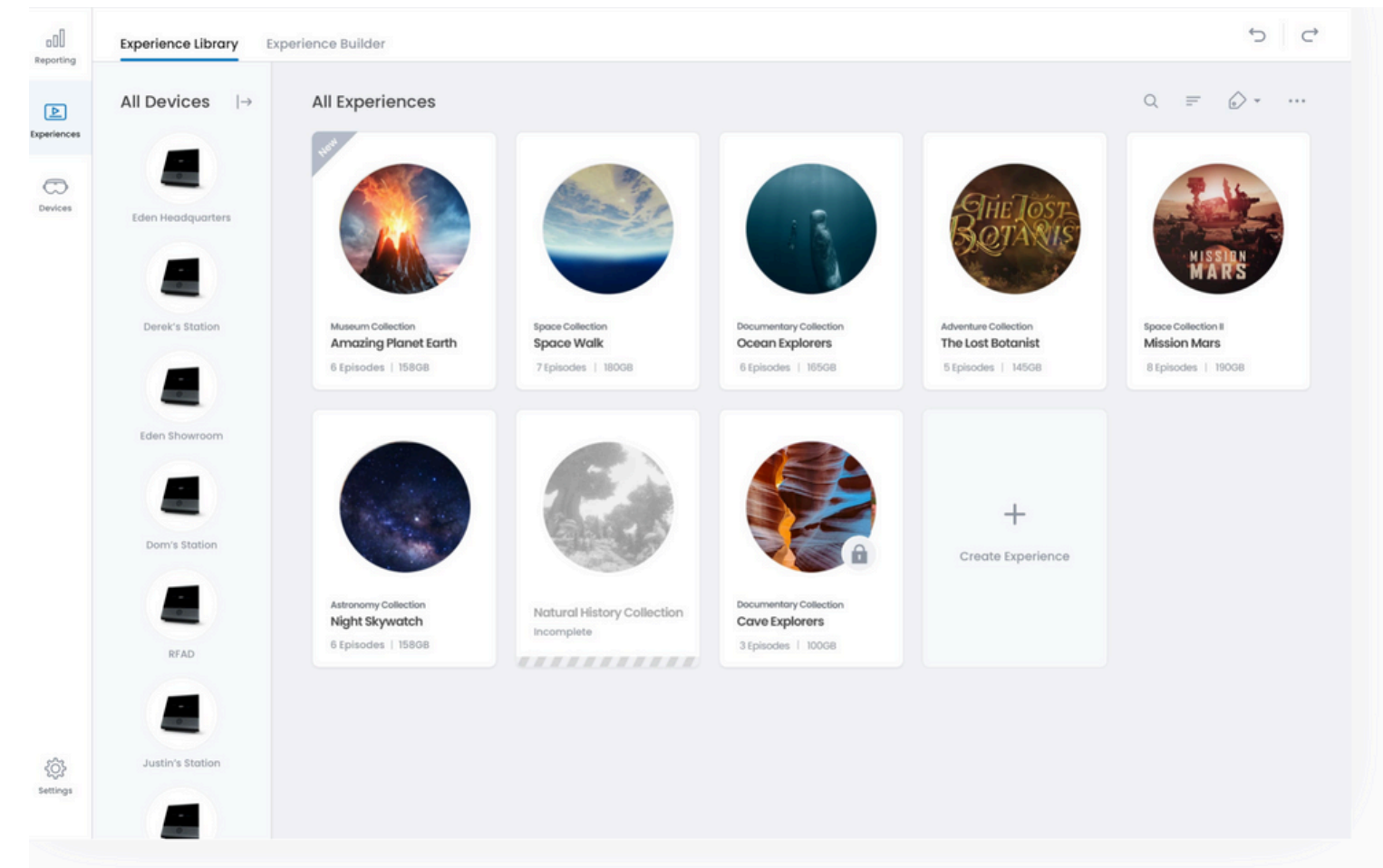
Intro to VR System

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



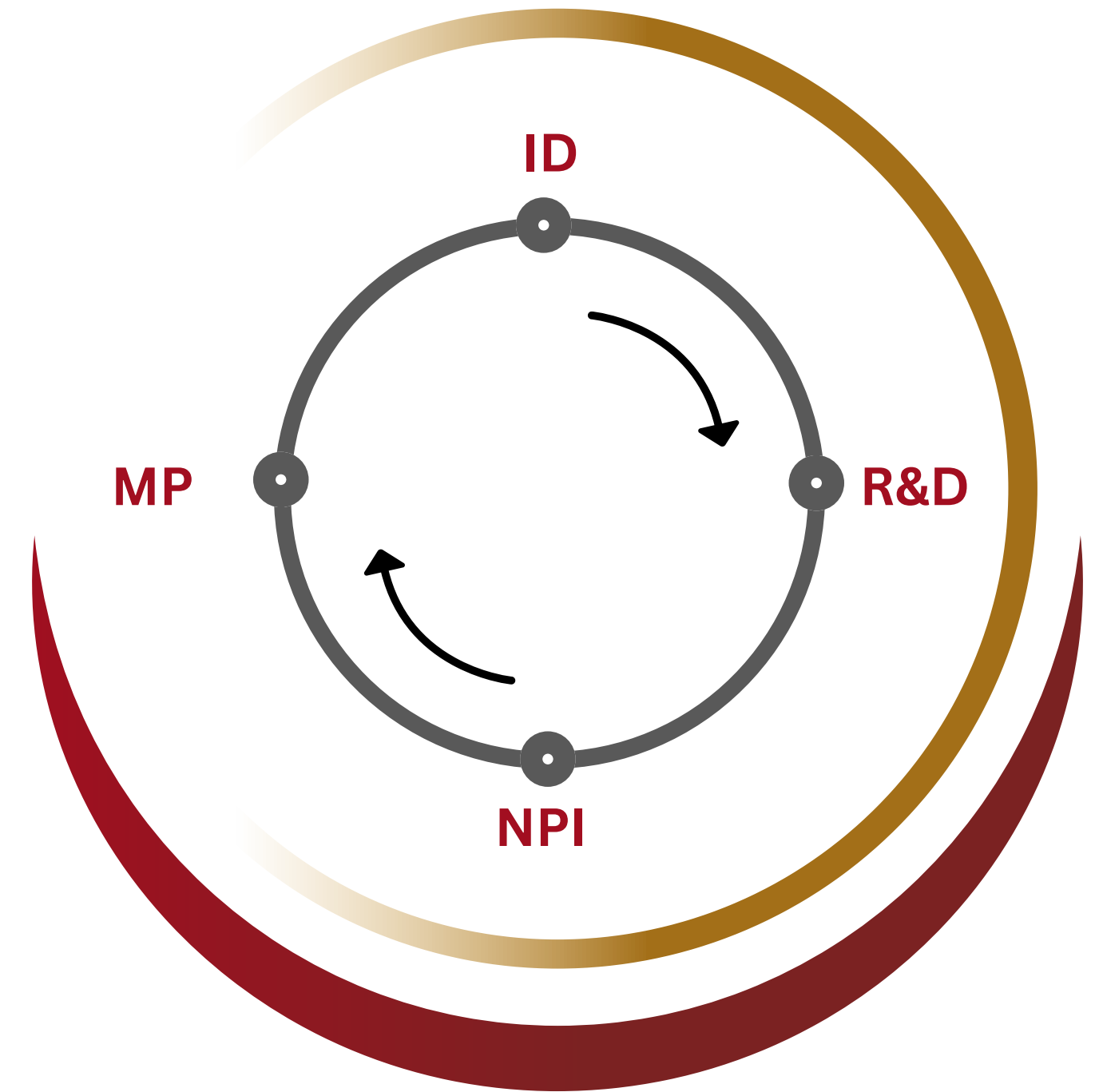
Software Backend for Content and Fleet
Management

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:

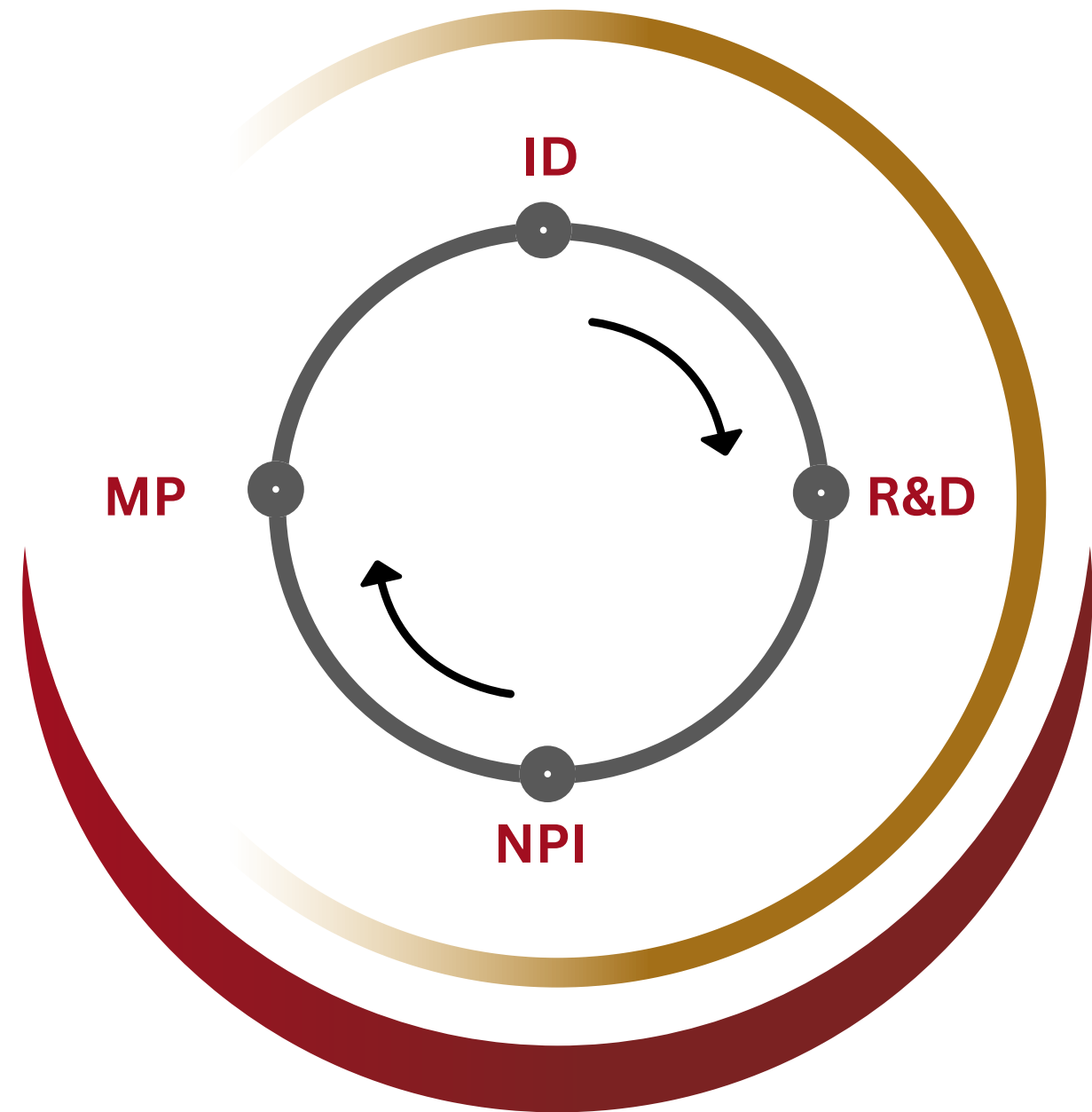
1. Ideation and Industrial Design (ID)
2. Research and Development (R&D)
3. New Product Introduction (NPI)
4. Mass Production (MP)

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*

Product Requirements Document

CRADLE & NFC ANTENNA

N COIL
The S1 Cradle has an induction coil embedded inside the cradle (the right wing when looking from the top).

NFC ANTENNA
This reads the headset via antenna.

STAND

The Base Stand is made of 2 parts, **FRONT PLATE** and **BACK COVER**.

FRONT PLATE
The single-part structure is made from aluminium which has been spray-painted.

LED BOARD & LENS
This is a lens with 3 x LEDs behind it which will indicate the charging status.

STAND (UNDER SIDE)

AIR VENTS
There are two channels (one on either side) to allow for airflow to cool the electronics.

SNACKER MAIN PCBA
The base will house the Snacker Main PCBA above the weight and insulated from the weight.

COLOUR

PANTONE Cool Gray 10 C

| | |
|--------------------|-------|
| PANTONE Blue 072 | 5.40 |
| PANTONE Black | 12.60 |
| PANTONE Trans. Wt. | 82.00 |

PANTONE® Cool Gray 10 C

CMYK: 40 30 20 65
RGB: 99 102 156
HTML: #636666

HANDLE GRIP CABLE CHANNEL

CABLE CHANNEL
The Handle Grip needs a channel in it (NOT IN THE STEP FILE) to hold a cable in the Tethered Version.

CABLE CHANNEL PLUG
When there is no cable installed, it will require a plug that can cover the hole seamlessly.

ZIG-ZAG
Zig-Zag style disruption to be added to provide security to the cable if pulled from the bottom.

COVER OFF **COVER ON**

TOUCHSCREEN **SINGLE BOARD PC** **LTE MODULE** **NFC ANTENNA**

KIOSK MAIN PCBA **OPTIONAL SSD** **INTERNAL SPEAKERS** **EXTERNAL WIFI ANTENNA** **EXTERNAL LTE ANTENNA**

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

| | |
|------------------|---|
| CPU | Intel 8th Gen Celeron Processor N4100 |
| CORE | 11-2.4GHz 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 | L130mm 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

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

Deliverables

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

Critical

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

Risks

Product Designers, Industrial Designers, UX Designers

DRIs

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

Research & Development

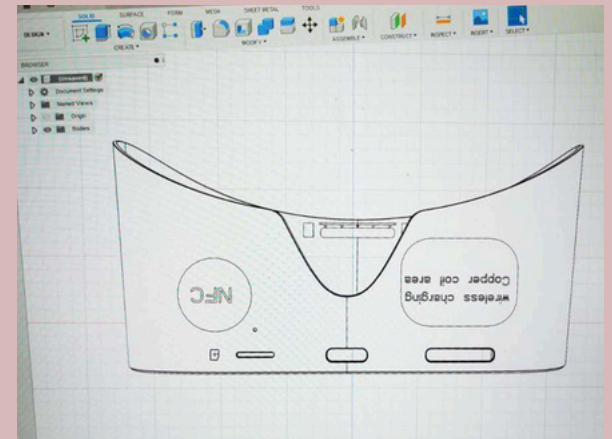
Marathon, not a sprint! Or maybe a triathlon...

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

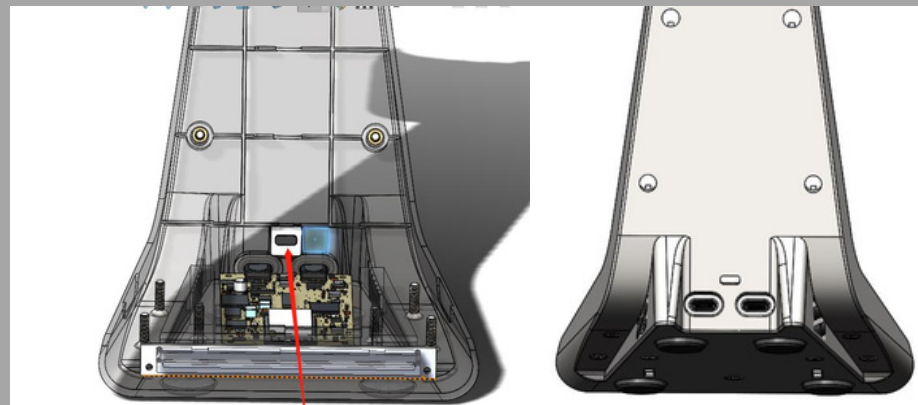
VR Headset R&D



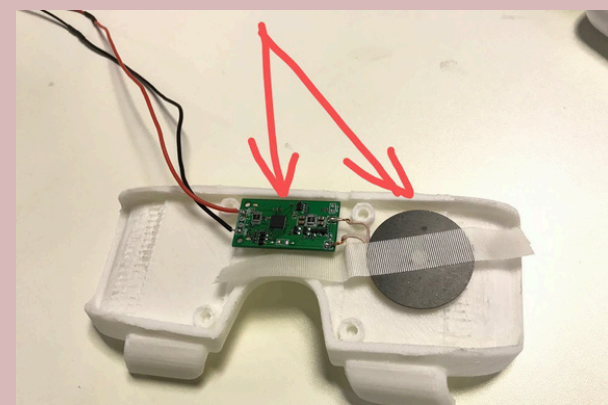
Latch Mechanism Design & Glue Assembly



2nd Derivative Continuous Curvatures



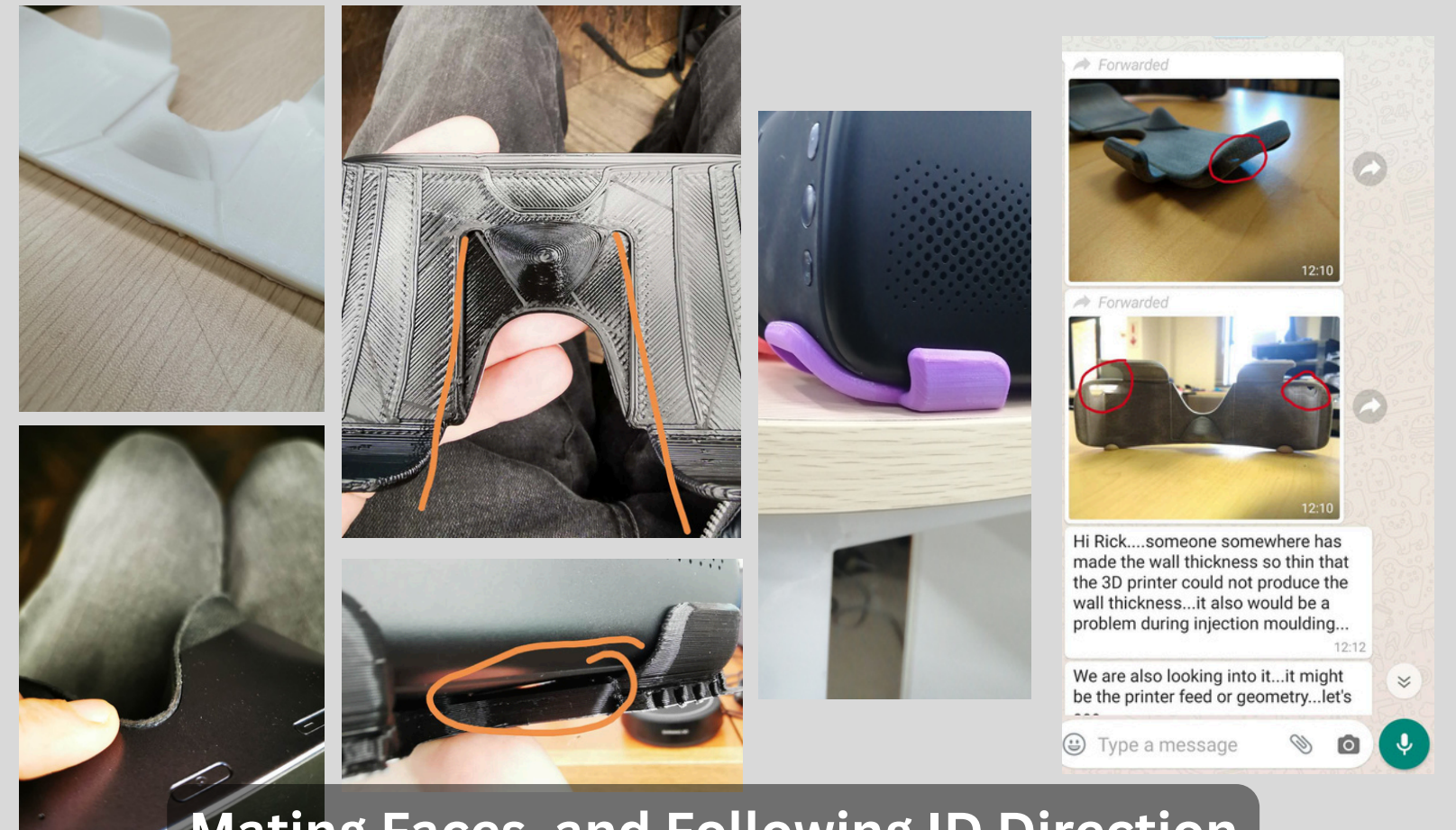
Kensington Lock Integration



Internal Architecture

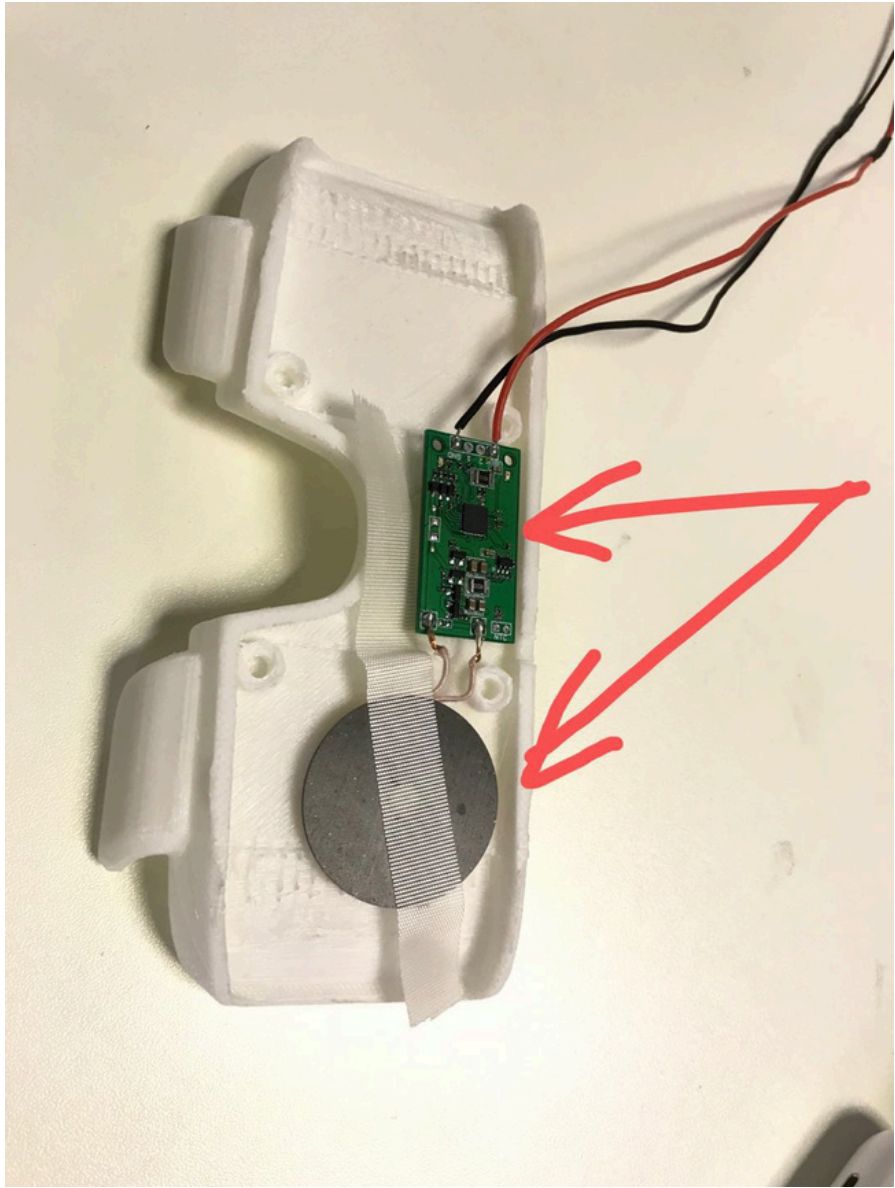
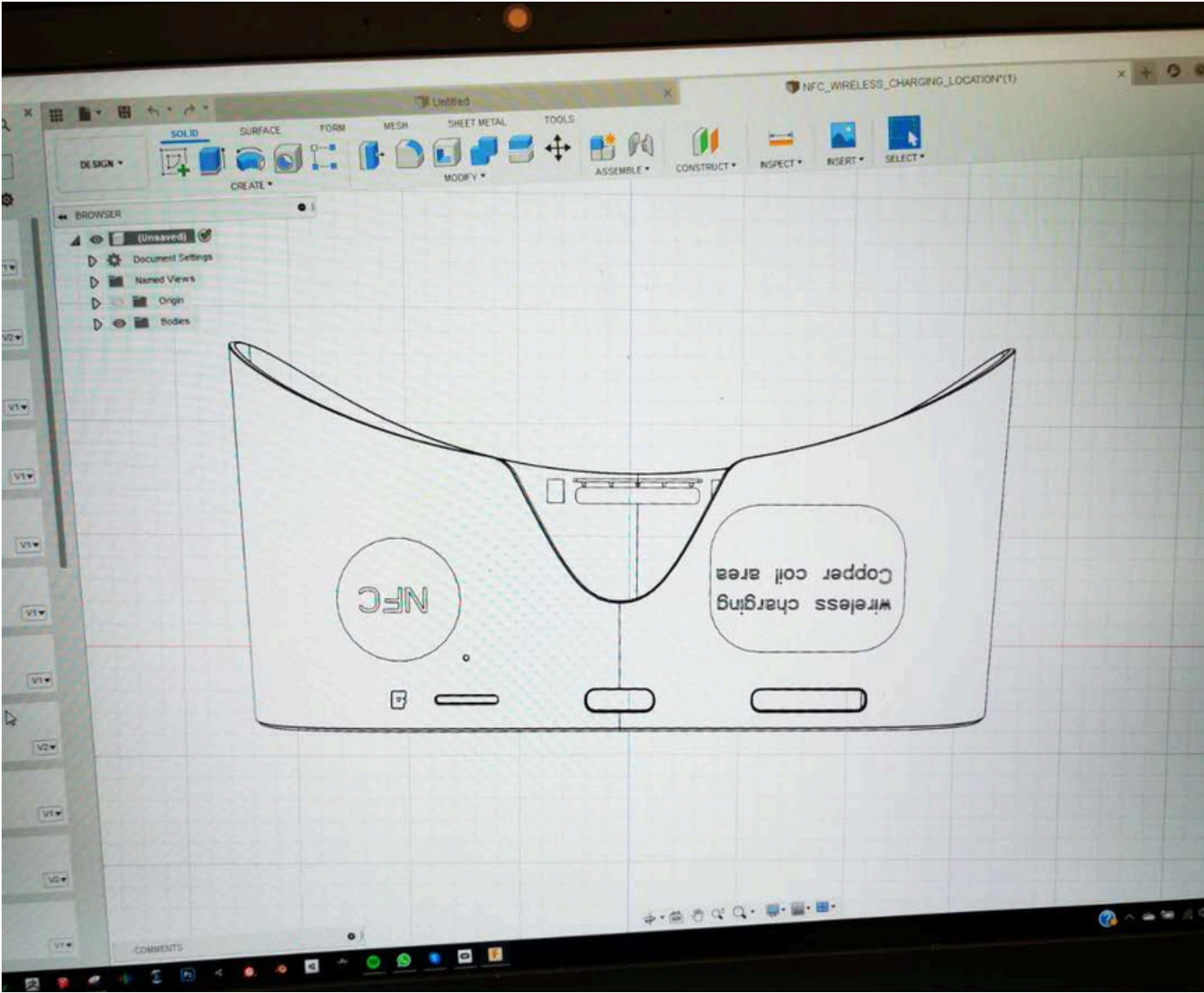


Headset Manufacturer Collaboration and QC



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

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

Goal

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

Deliverables

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

Critical

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

Risks

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

DRIs

New Product Introduction

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

After your "golden sample," work continues!



Prepare (and droptest) Packaging

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 | 0.454-9.521 | 30 | 76.20 |
| 21-40.99 | 9.526-18.893 | 24 | 60.96 |
| 41-60.99 | 18.897-27.685 | 18 | 45.72 |
| 61-80.99 | 27.689-36.477 | 15 | 38.10 |



Testing (left side surface)



OEMs for Custom Label Accessories

SPECS 参数

Model: PD451B(1C)

FOLD US

- Input: AC100V-240V 1.2A 50-60Hz
- Output: USB: 5V3A/9V3A,12V3A
- Size: EU/US(90/53)x28x53mm
- Color: Black/White(半文半光面)
- Texture: PC+防火阻燃(钢琴)
- 配件: 无(裸机/铜壳磨砂)

15V3A,20V2.25A(45W Max)

Order Information

订单号: 80338037967252436
 订单总金额: 120.00元
 订单日期: 2020/07/28 09:42:41
 收货人: 陈国雄
 收货地址: 广东省 深圳市 福田区 益田街道 益田大厦 709
 手机: 17704241370
 电话: 86-0755-89333009

Product Information

商品名称: 深圳华强高科技术有限公司
 商品型号: 深圳华强高科技术有限公司
 商品品牌: 深圳华强高科技术有限公司
 商品规格: info@hqwtech.com
 商品重量: 1340.00g
 商品体积: 1340.00cm³
 商品颜色: 1340.00cm³
 商品材质: 1340.00cm³
 商品产地: 1340.00cm³

Order Summary

| 商品 | 单位 (元) | 数量 | 优惠 (元) | 商品状态 | 商品总价 (元) |
|-------------------------|-----------|----|-------------|-------|----------|
| 15V3A,20V2.25A(45W Max) | 120.00元/件 | 1 | 商家折扣: 0.00元 | 已确认收货 | 400.00 |

Lockdown Supply Chain

| 序号 | 产品名称 | 产品图片 | 单位 | 材料 | 产品尺寸/mm | 模具材料 | 加工内容 | 模具尺寸/mm | 产品单价 (含税/不含税) | 产品数量 (件) | 开模费用 (元) | 备注 |
|-------------|------------|------|---------|--------|-------------|-------|------------|-------------------|---------------|----------|----------|-------------|
| 1 | 后壳 | | 1x1 | PC+ABS | 285x144x207 | S1308 | 模具设计 制造与注塑 | CT-3090 4300 8150 | 449.0 | 225000.0 | 49.50 | 50个打位 10个打模 |
| 2 | 底壳 | | 1x1 | PC+ABS | 284x200x28 | S1308 | 模具设计 制造与注塑 | CT-4543 879 380 | 163.0 | 113000.0 | 16.40 | 50个打位 3个打模 |
| 3 | 后壳+外上壳+外下壳 | | 1x1+1+1 | PC+ABS | 125x47x10 | S1308 | 模具设计 制造与注塑 | CT-3560 879 380 | 18.0 | 32700.0 | 3.20 | |
| 4 | 橡胶脚 | | 1x1x4 | 硅胶 | 10x10x6 | S1308 | 模具设计 制造与注塑 | | 0.5 | 8500.0 | 0.15 | 25 |
| 5 | 橡胶脚零件 | | 1x1x1 | 硅胶 | 40x40x4 | S1308 | 模具设计 制造与注塑 | | 1.0 | 6800.0 | 0.80 | 25 |
| 模具总金额 (大写): | | | | | | | | | 386000.0 | 74.25 | | |

Get Manufacturer Quotes & DFM

工厂审核 Factory Audit

1. 工厂审核目的

2. 审核范围

3. 审核标准

4. 审核流程

5. 审核报告

Production Line Audits and Reviews



Trademarking & NNN Agreements

| 客户 | 模具号 | 产品名称 | 规格 | 数量 | 单价 | 总价 |
|-----|-----------|---------|-------|-------|------|------|
| AMT | 202014029 | 3分卡环 | PC998 | 25000 | 0.08 | 2000 |
| AMT | 15-110卡环 | 710卡环 | PC108 | 25000 | 0.08 | 2000 |
| AMT | 1寸堵头 | 1寸堵头 | AM724 | 25000 | 0.08 | 2000 |
| AMT | 4分快拆中接头 | 4分快拆中接头 | AM729 | 25000 | 0.08 | 2000 |
| AMT | 2019024 | 集成水刺喷头 | AM739 | 25000 | 0.08 | 2000 |
| AMT | 2019041 | 2分打管喷头 | AM739 | 25000 | 0.08 | 2000 |
| AMT | 2019040 | 2分打管喷头 | AM739 | 25000 | 0.08 | 2000 |
| AMT | 2019009 | 2分打管喷头 | AM739 | 25000 | 0.08 | 2000 |



Factory Tours and Samples

Assembly Instructions

1. Connect the RF cable to RF antenna
2. Plug LED PCB, wireless charging and NFC antenna onto 4G PCB board to be Stand PCBA assembly#1
3. Position the Lightguide to Front cover and then use 3 screws (M3x12) to fix the PCB board onto the front cover to be Stand PCBA assembly#2
4. Put the wireless charging and NFC antenna onto the front cover to be Stand PCBA assembly#3
5. Put the wireless charging and NFC antenna onto the front cover to be Stand PCBA assembly#4

Assembly Instructions

FC

RoHS

CE

Certification Testing

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

- 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

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

- 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

Critical

Risks

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

DRIs

Deliverables

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



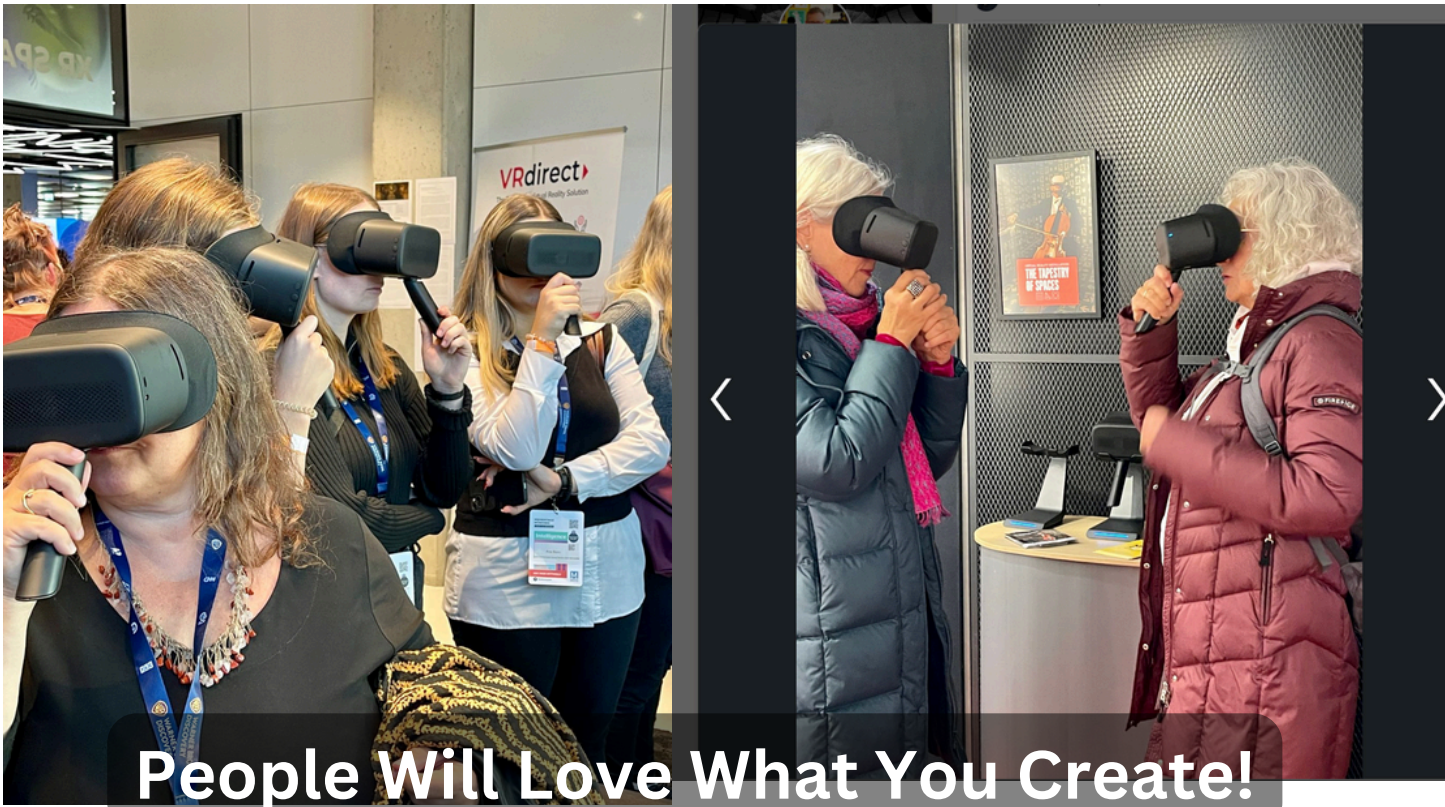
Ensure Checks for Stable Production!



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.

- Your product, over and over again

Deliverables

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

Critical

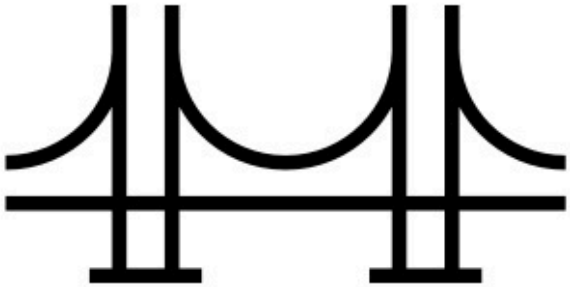
- Inflexible to customer demand or design changes
- Capital intensive initialization
- Low yield / poor QC leading to high return rate
- Supply Chain blocked

Risks

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

DRIs

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



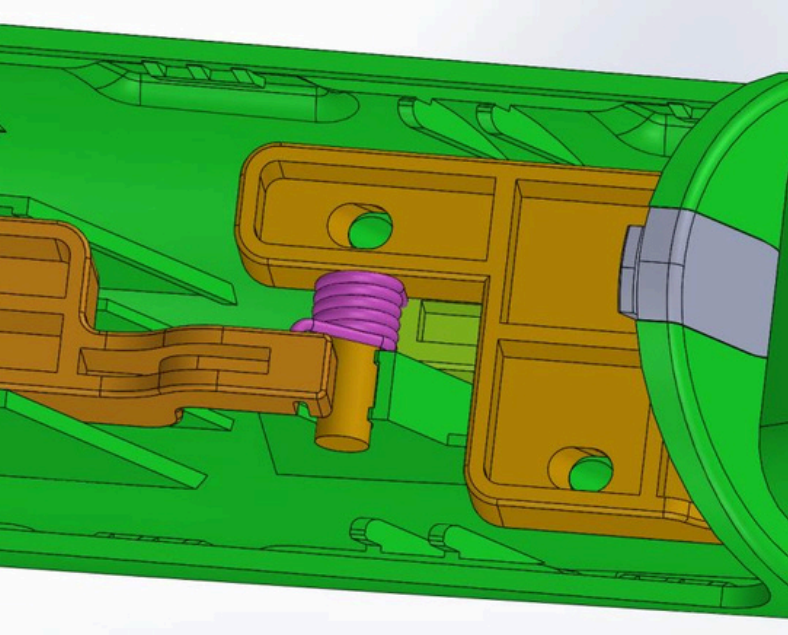
Monitor Progress

On-site audits and inspections to ensure development success

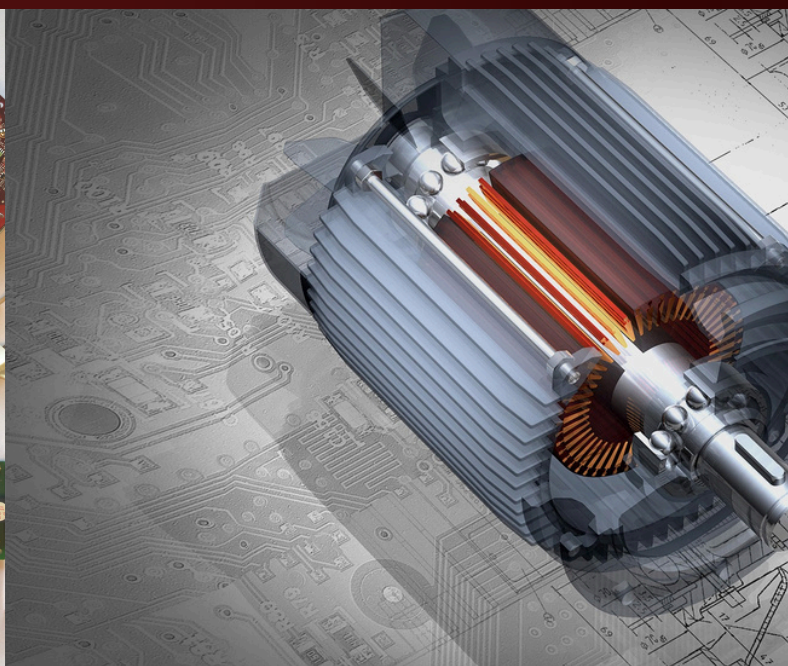
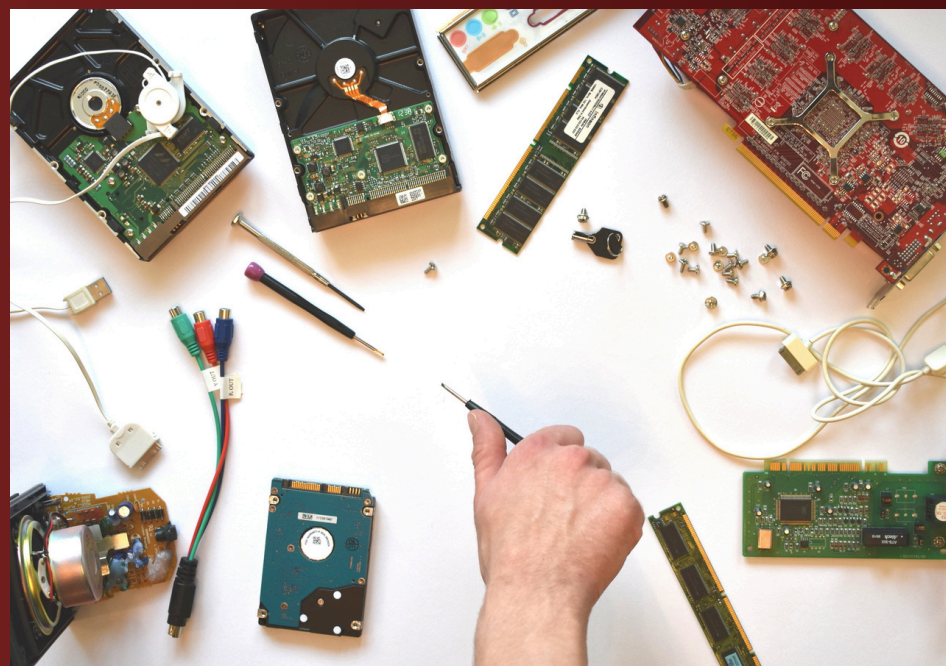


Streamline Success

Integrating quality control processes for repeatable production



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



Our team is diverse, qualified, 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



Health Diagnostics Platform

Sourcing & Hardware Development



Portable Charging Solutions

Sourcing & Hardware Development



Hygiene Products

Sourcing & Brand Development



Countertop Sprout Grower

Quality Control

BILL & MELINDA
GATES *foundation*

GH+
Labs

Pixa



manila.

FORAGES™

Let's talk soon!



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