2023-2024 VEX VRC High School
Reverse Engineering Challenge
Disassembly and Analysis of a 2nd Generation iPad Mini

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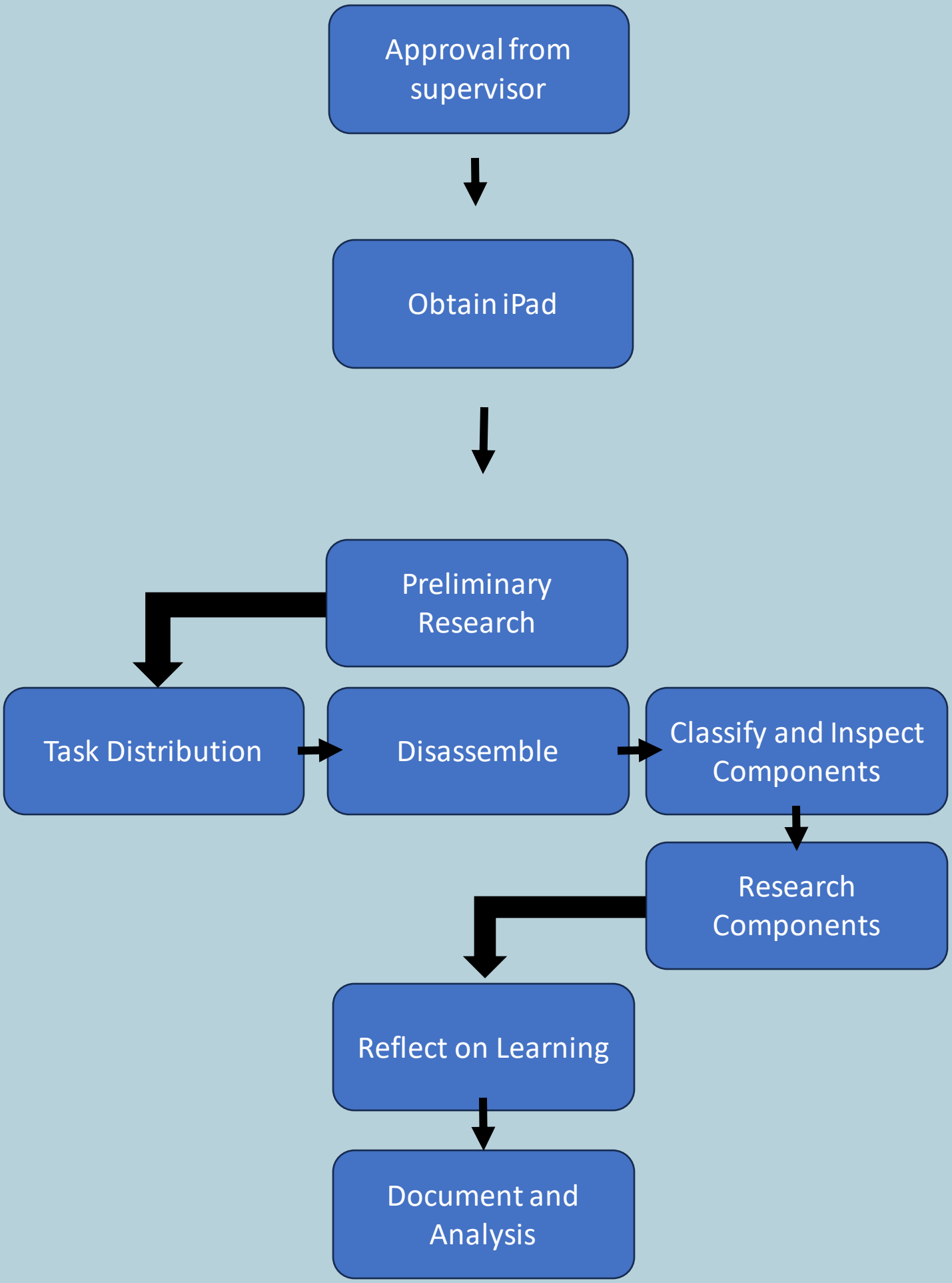
Introduction

The Team

We are team 934Z, the Towson Terminators
After winning the state championship in 2020, the team has fallen from success in the high school robotics world. With the COVID-19 pandemic and seniors moving on , the team has gone through some restructuring. Now, to contribute to bringing the team back to glory, we have decided to participate in the 2024 Reverse Engineering Challenge.

Plan of Action



iPad Evolution

The Original iPad

ANNOUNCED: Jan. 27, 2010

RELEASED: April 3, 2010

KEY FEATURES: 9.7-inch 1024x768 screen; 1GHz A4 processor; 10-hour battery

PRICE: $499

The iPad 2

ANNOUNCED: March 2, 2011

RELEASED: March 11, 2011

FEATURES: Still camera and video recording; faster processor; thinner and lighter

PRICE: $499

The iPad (3rd Generation)

ANNOUNCED: March 7, 2012

RELEASED: March 16, 2012

KEY FEATURES: High-def Retina display; 4G compatibility

PRICE: $499

The iPad Mini

ANNOUNCED: Oct. 23, 2012

RELEASED: Nov. 2, 2012

KEY FEATURES: Reduced size and weight; fourth-generation wireless capabilities

PRICE: $329

The iPad Air

ANNOUNCED: Oct. 22, 2013

RELEASED: Nov. 1, 2013

KEY FEATURES: Thinner and lighter; 64-bit Apple A7 processor; stereo speakers

PRICE: $499

The iPad Mini 4

ANNOUNCED: Sept. 9, 2015

RELEASED: Sept. 9, 2015

KEY FEATURES: Apple A8 processor; improved cameras

PRICE: $399

The iPad Pro

ANNOUNCED: Sept. 9, 2015

RELEASED: Nov. 11, 2015

KEY FEATURES: 12.9-inch screen, Apple Pencil system

PRICE: $799

The iPad (6th Generation)

ANNOUNCED: March 27, 2018

RELEASED: March 27, 2018

KEY FEATURES: Faster A10 processor, Apple Pencil support

PRICE: $329

iPad Pro (3rd Generation)

ANNOUNCED: Oct. 30, 2018

RELEASED: Online orders begin October 30 with availability starting November 7

KEY FEATURES: Liquid Retina Display; all-screen design; A12X Bionic Chip; Face ID

PRICE: 11-inch, $799+; 12.9-inch, $999+

iPad Pro (5th Generation)

ANNOUNCED: April 20, 2021

RELEASED: Online, April 30; in stores starting late May

KEY FEATURES: M1 chip, ultra-fast 5G, and 11- or 12.9-inch Liquid Retina XDR display

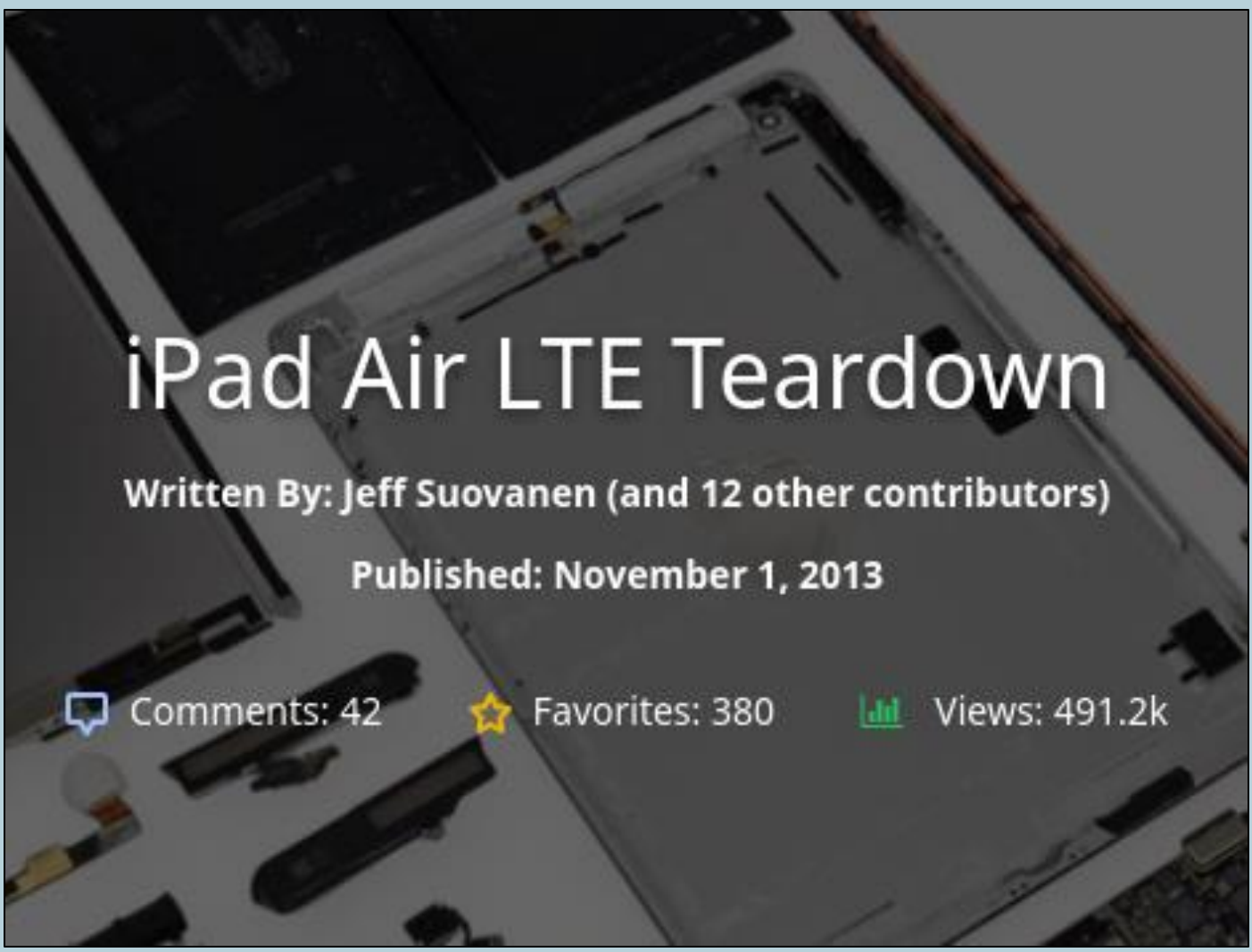
PRICE: 11-inch, $799+; 12.9-inch, $1,099+

« *Shown here with Apple's Magic Keyboard for iPad Pro*

Preliminary Research

Preliminary Research

Going into this project, we had experience with tools and assembly from constructing robots. However, disassembling an iPad is a different process. There are few screws in the initial disassembly, thus we decided to research the proper method of disassembling an ID. Jeff Suovanen published an article on ifixit.com in 2013. This article provided us with the necessary precautions and knowledge.



Disassembly

Tools

Heat Gun

- Wagner HT1000 Heat Gun
- Max Wattage: 1,200W
- Provided by teacher

Guitar Pick(3)

- Standard guitar pick
- Provided by teammate
- Nylon Material

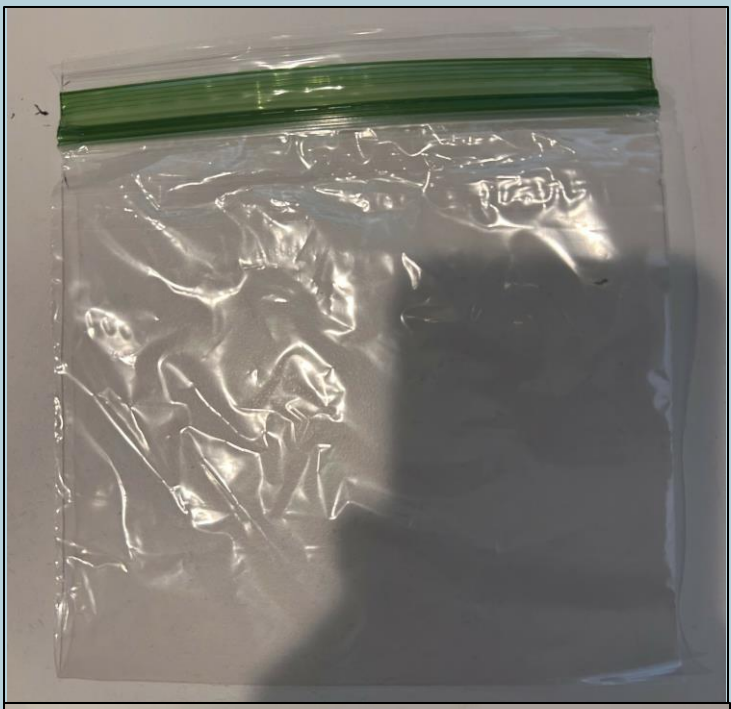
Screwdrivers

- Sizes (mm): 2.0, 2.4, 3.0
- 6-Piece Precision screwdriver set
- Stanley Tools

Safety Precautions

Plastic Bag

- Store small parts and any waste



Safety Goggles

- Protect eyes, proper vex safety guidelines

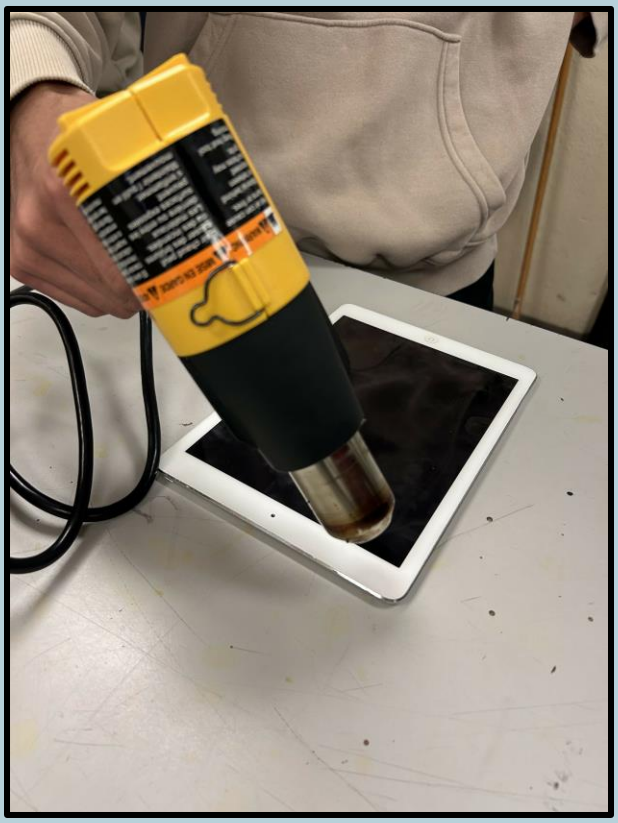
Gloves

- Protect our hands, handle disassembly more efficiently
- Provided by teammate

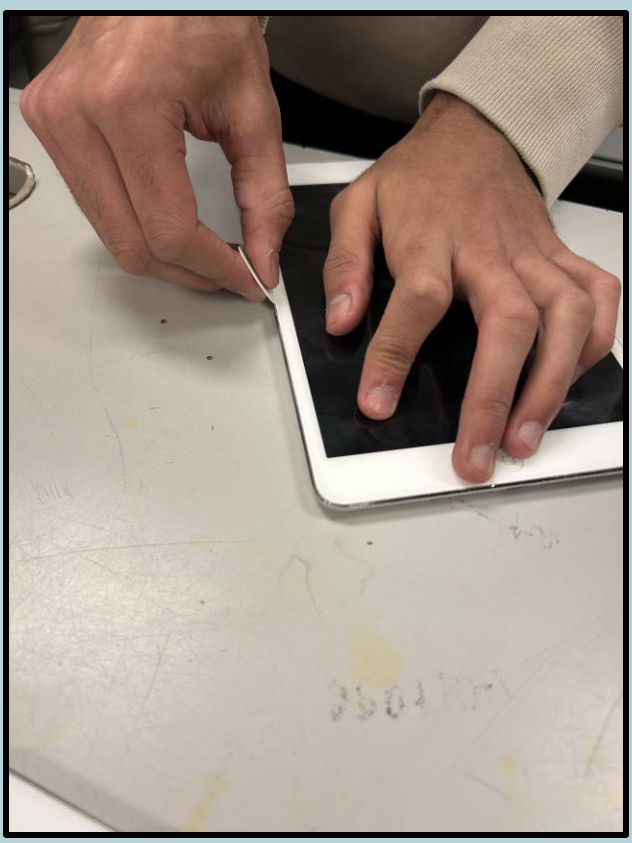
Disassembly Process

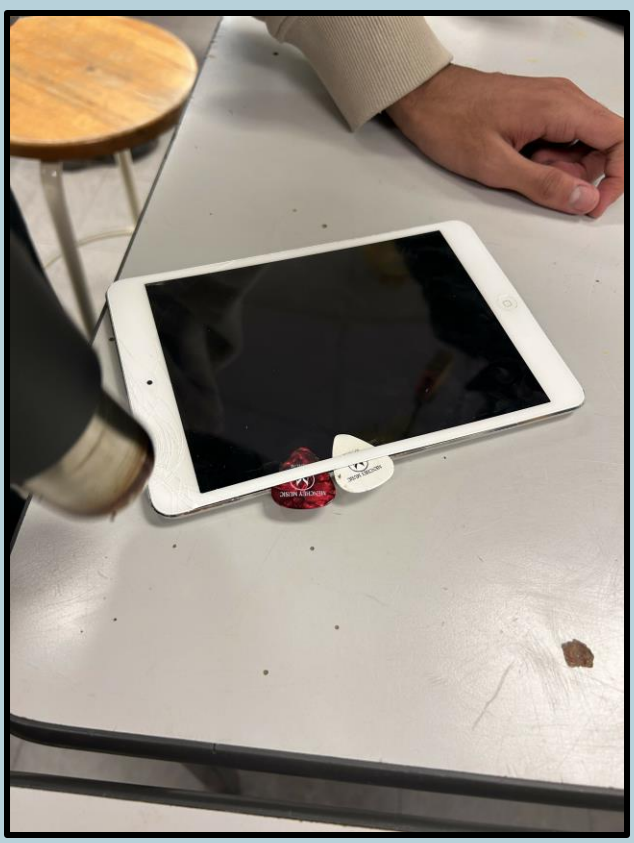
Step 1 – Obtain Tools and Safety equipment

Step 2 – Heat Up Glue on the iPad

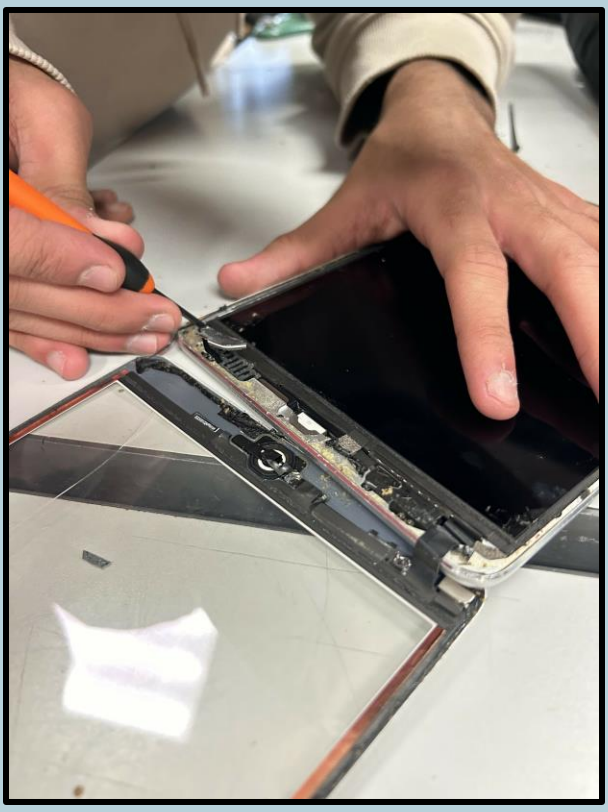


Step 3 – Insert Guitar Picks Underneath Screen



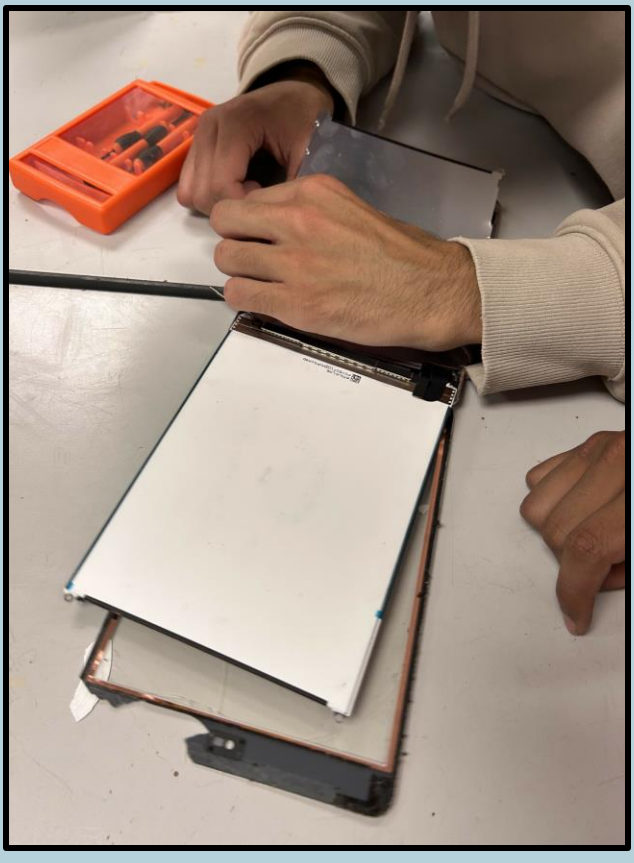


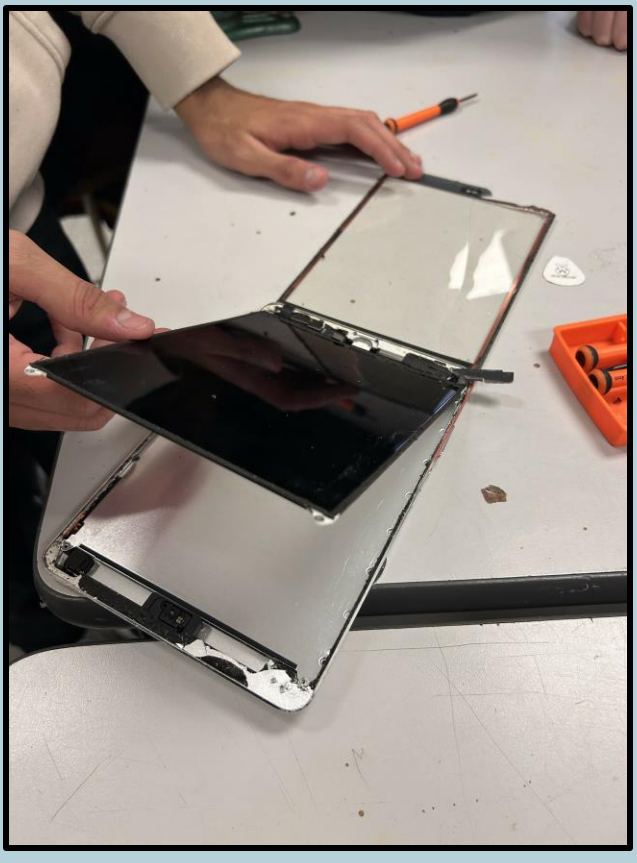
Step 4 – Remove Glass Screen



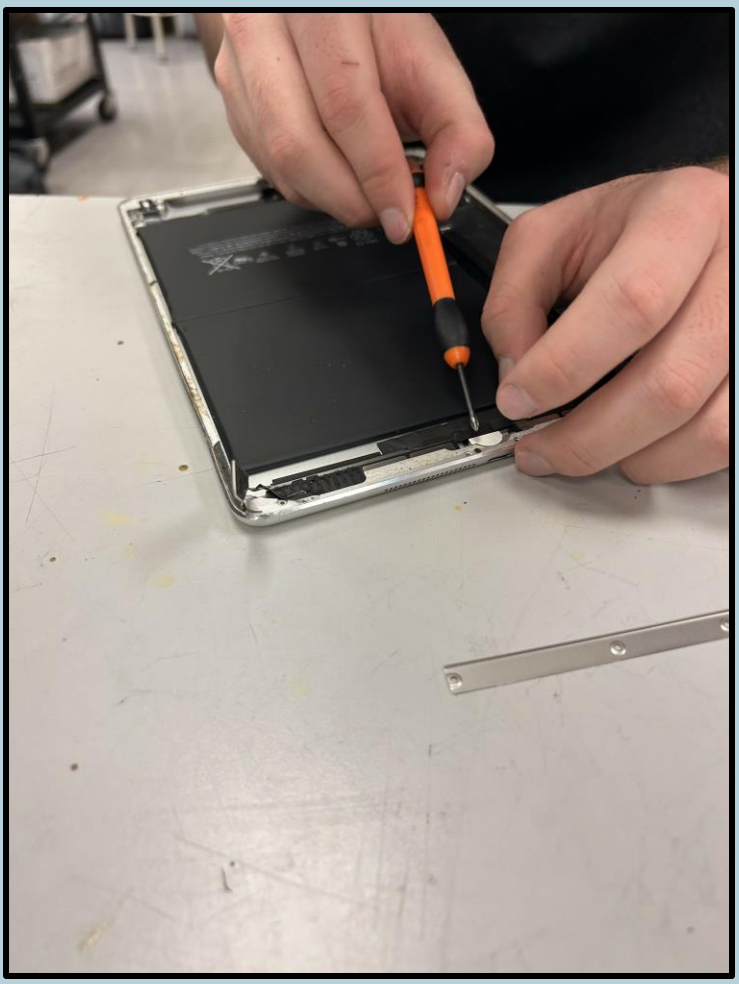
Step 5 – Remove Inner Frames and Connector Covers

- Many screws removed





Step 6 – Remove Metal Connectors Along Border

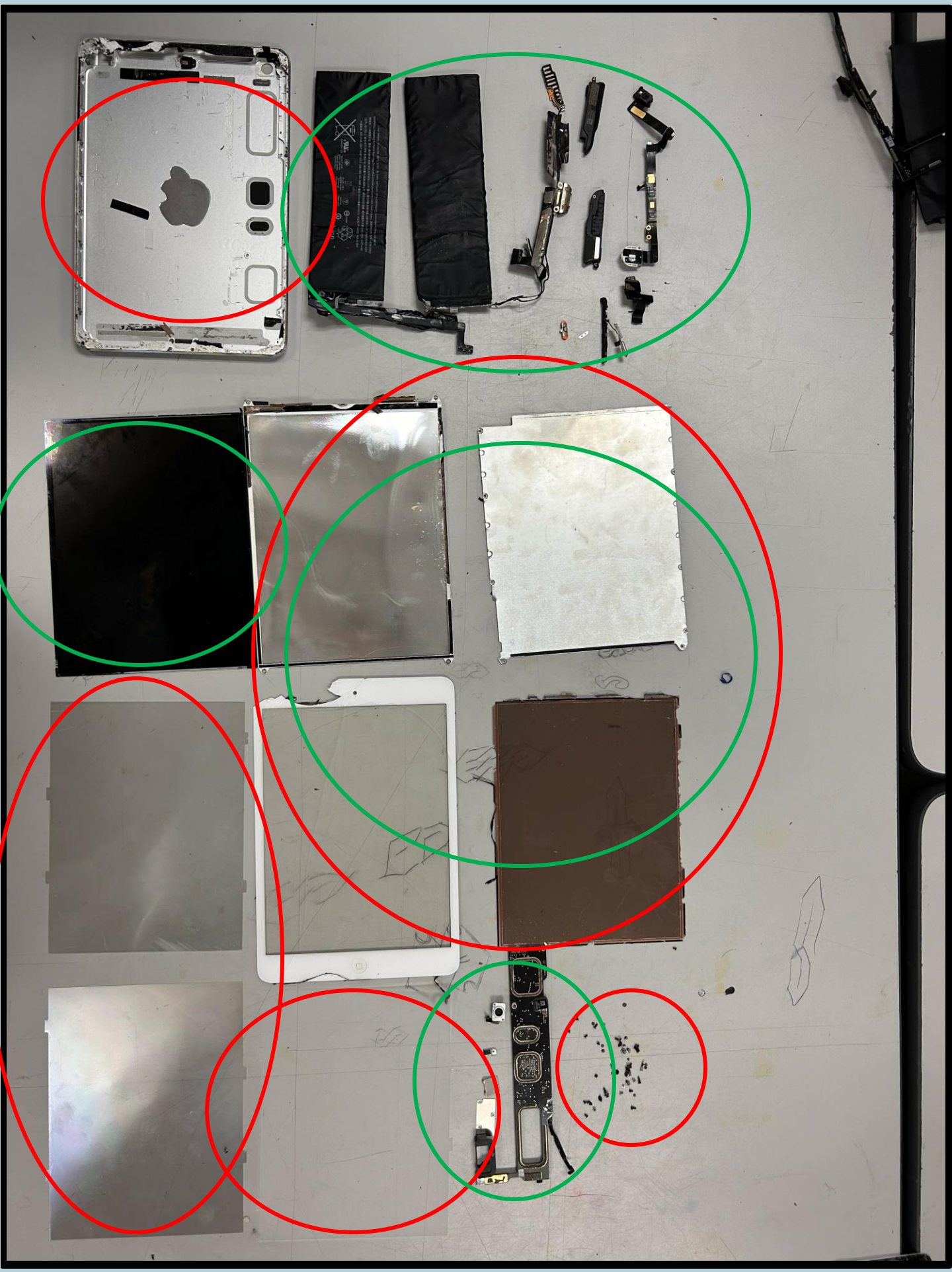


Step 7 – Remove Batteries

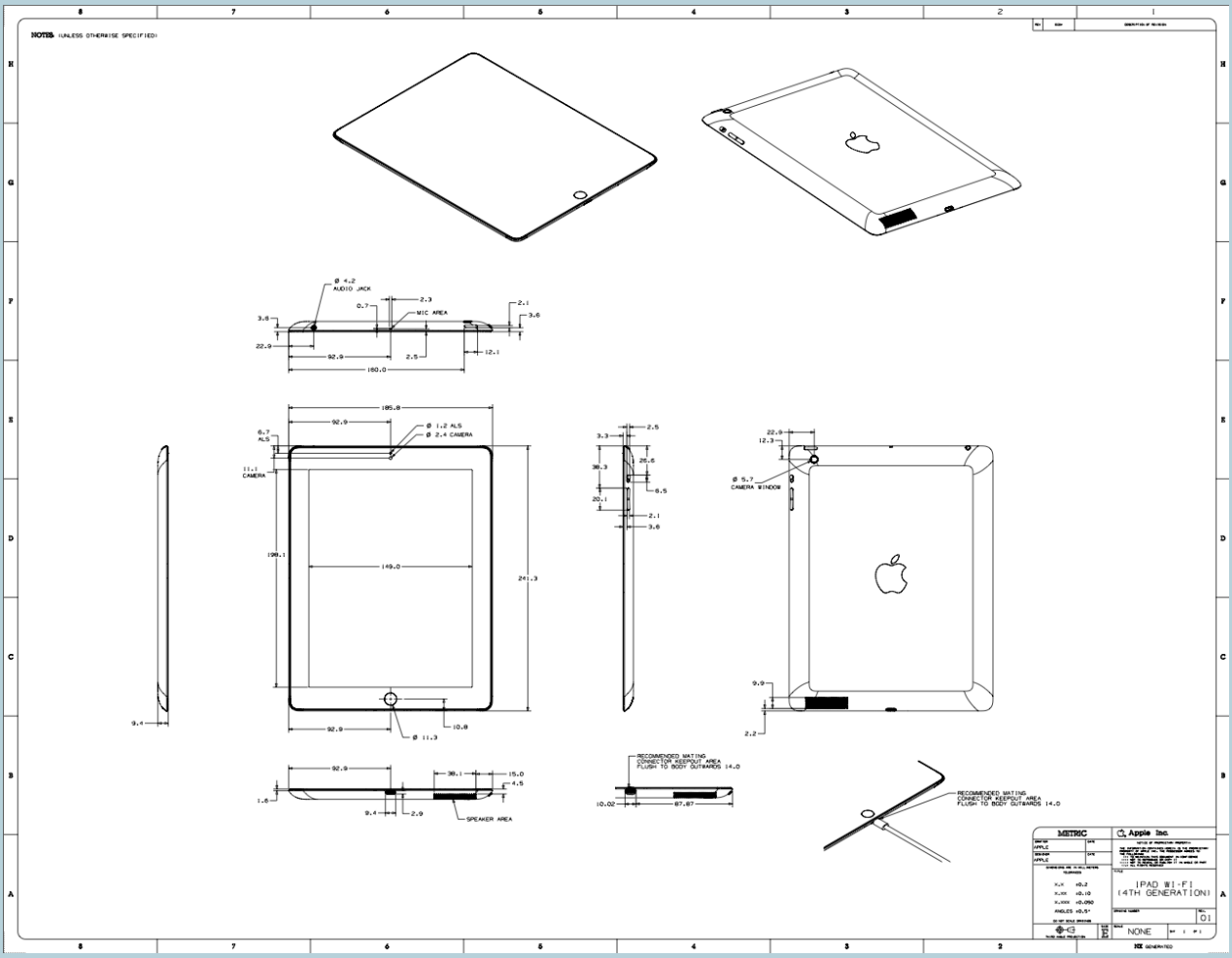
- Heat gun used to remove glue
- Removed any additional parts from shell

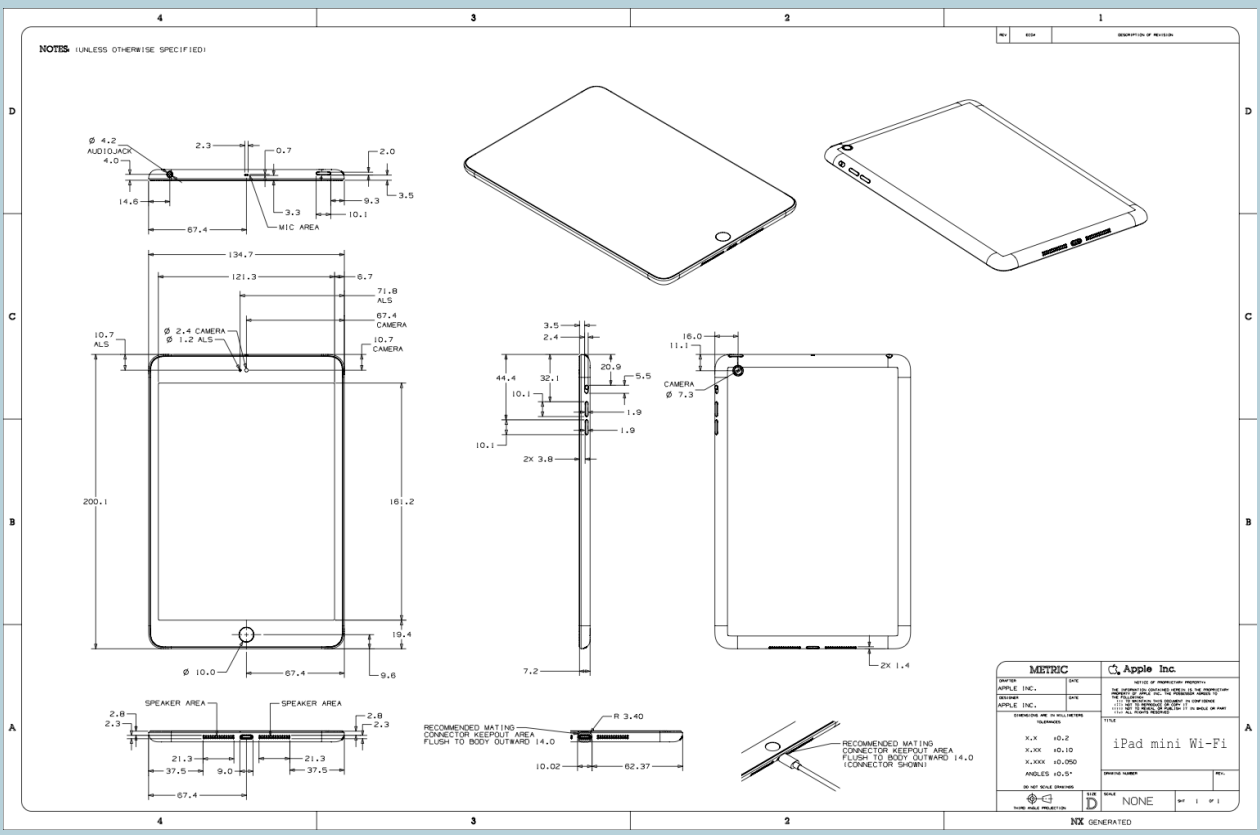
Results

Electrical and Non-Electrical



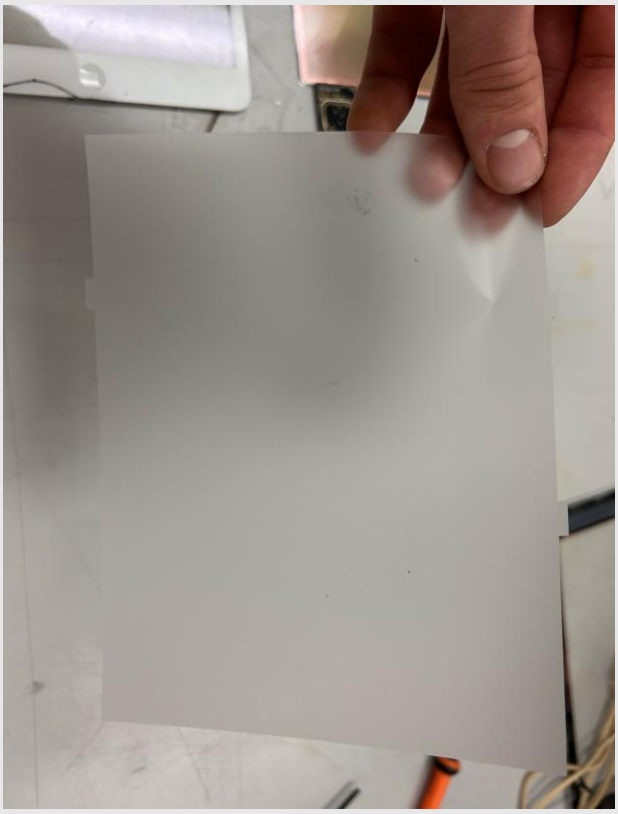
Schematic Diagrams





Components

Component & Description	Image
Touchscreen/Digitizer • Glass and ceramics • Manages the user's input	
Reflective Screen • Displays screen and light • Glass and minerals	

Component & Description	Image
Enclosure of iPad • Protects and provides structure for internal components • Latest iPads: 100% recycled aluminum for environmental benefit	
Polarizing Filter • Controls orientation of light entering and leaving the screen • Works to optimize visibility and contrast for users	

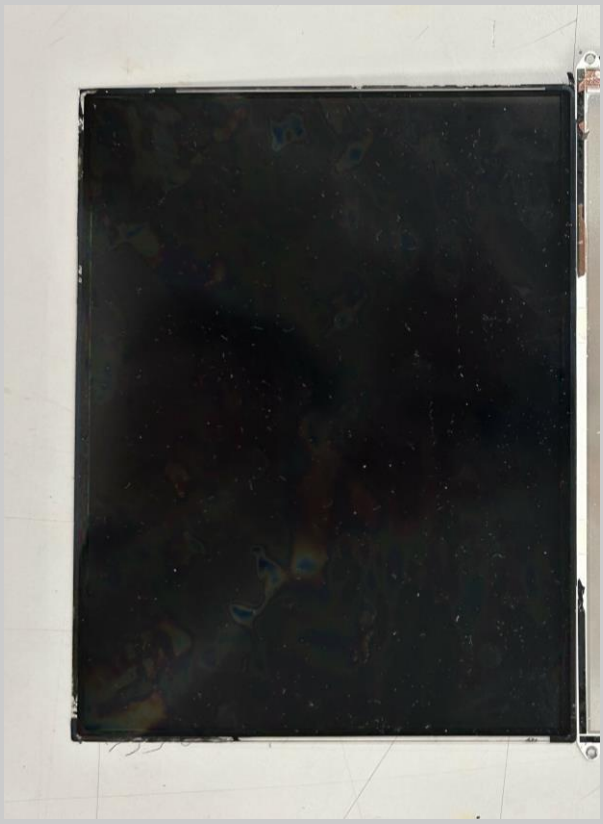
Component & Description	Image

Outer touchscreen

- Comfortable, safe touch for human fingertips
- Oleophobic coating applied to repel fingerprints and hand oil

Polarizing Filter

- Let's light waves through, oscillating in a certain direction while blocking perpendicular waves

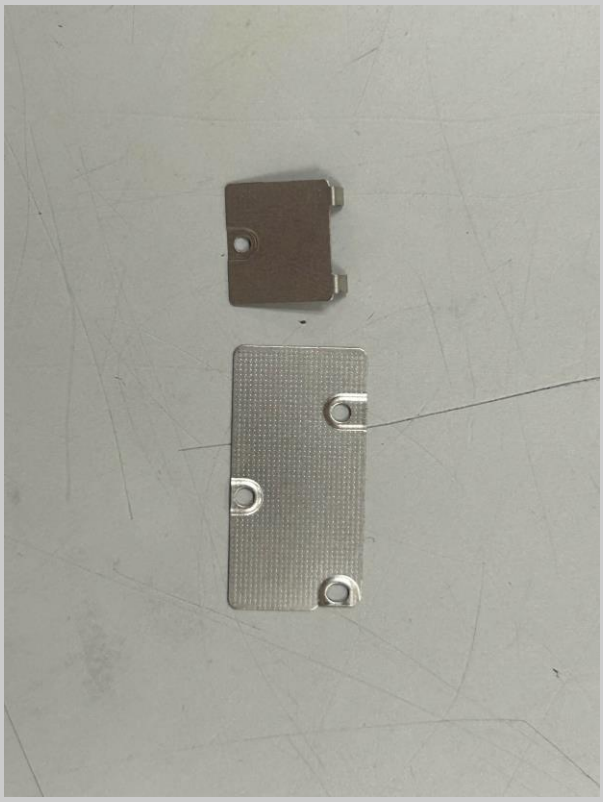
Component & Description	Image
Liquid Crystal Display Module (LCD) • Renders texts and images for the screen output. • Liquid crystals in the nematic phase – basic compound form.	
Part of LCD • We were able to feel liquid crystal on the screen • Changes orientation to manage light and create images	

Component & Description	Image
Pentalobe screws • Connect components of iPad and reinforce strength • Tamper-resistant	
Backlight • Rearmost layer of the LCD • Controls the amount of light that passes through screen and colors.	

Component & Description	Image
Protective Screen • Enhances durability and performance with anti-reflective coating • Thin and light weight adding to iPad **mini's** intent	
WLAN PCB • WLAN = Wireless Local Area Network • Location, downloading, messaging, internet, Bluetooth, data	

Component & Description	Image
Front Camera Frame • Aligns, protects, houses, and integrates front camera into display • Made of plastic	
Main Printed Circuit Board (PCB) • Connects and allows different components to connect	

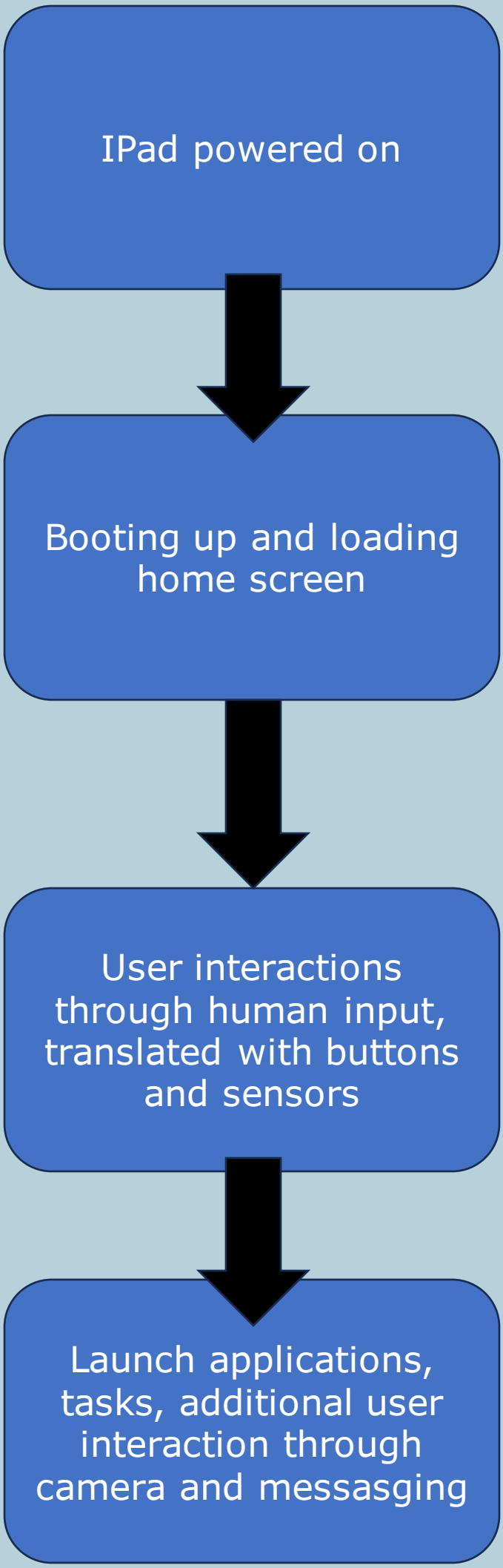
Component & Description	Image
External Buttons • Converts user input for electronic components • Made of aluminum and padding	
Sensor PCB • Sensor responsible fo r orientation, motion, proximity, and ambient light (brightness) • Sensors, accelerometer, gyroscope	

Component & Description	Image
Electrical Conductors • Circuit connectivity, power distribution, route signaling	
Rear Camera Module • Captures light and converts it to electric signals • Photographs with lens, autofocus, system image signal processor	

Component & Description	Image
Main Connector PCB • Central hub for internal connections, power distribution, communication interface, and charging • Integrated circuits, microcontrollers	
Loudspeaker Assembly • Manages audio output, alerts/notifications, and enhances multimedia experience • Components include voice coil, enclosure, magnet system	

Component & Description	Image
Battery Connectors • Manages charging, power distribution, electrical connection • Conductive, insulating materials	
Battery Pack • Two lithium ion batteries • Charger passes current to the battery, lithium ions move from the cathode to the anode through the electrolyte	

Control Flow Chart



Improvements in Latest Model

- The 6th generation has many new features
  - Face ID
  - Liquid retina display
  - 2nd used touch id through home button, 6th uses touch id for fingerprint authentication
  - Powered by A15 bionic chip vs A7 in the 2nd

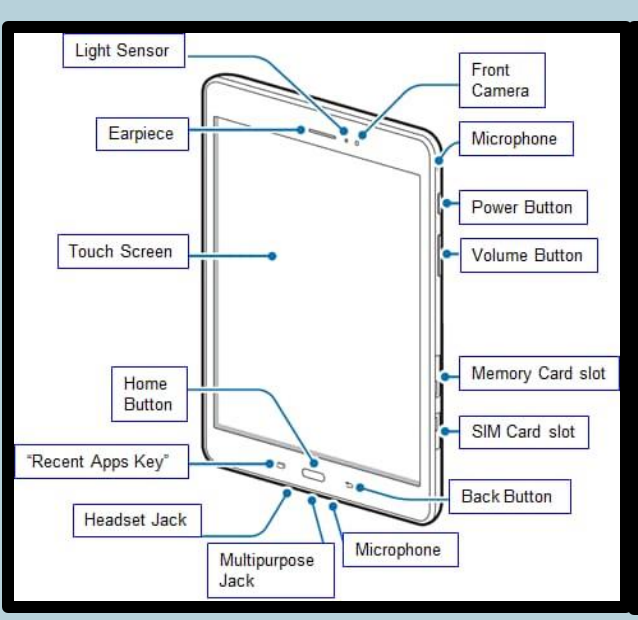
Apple Success Linked to Engineering Design?

Optimization

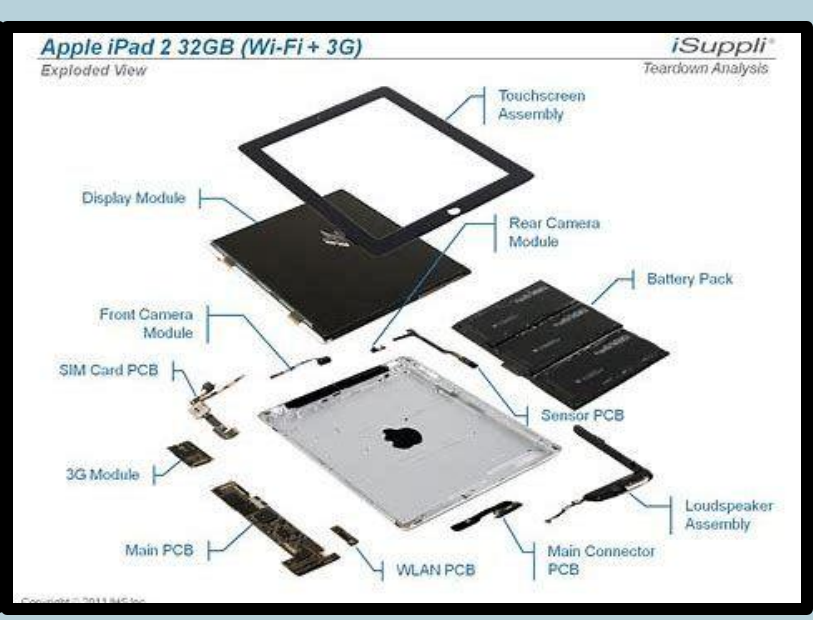
- Efficient power management as shown through the lithium battery structure and custom chips
- Lightweight product and parts structured well despite small size

Economic Strategy

- The device has it's lighting port permanently soldered to the logic board -> makes for expensive repairs, optimizing apple's profits
- Use of parts apple designs themselves (pentalobe screws) -> profit from repairs
- Vertical Integration – designs both hardware and software



Samsung Galaxy Tablet Diagram



iPad 2 Diagram

Conclusion and Reflection

- We have learned how to:
  - Safely disassemble, analyze, research electronic devices
  - Strategies behind Apple's success
- We are amazed on how complex and intricate an object we use on the daily to watch YouTube is after breaking it down

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