we made walkie talkies

Say hello to Laura and Mike!

But first...

akshay shivkumar

2nd year EECS

like minion

alex wong

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car

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franse

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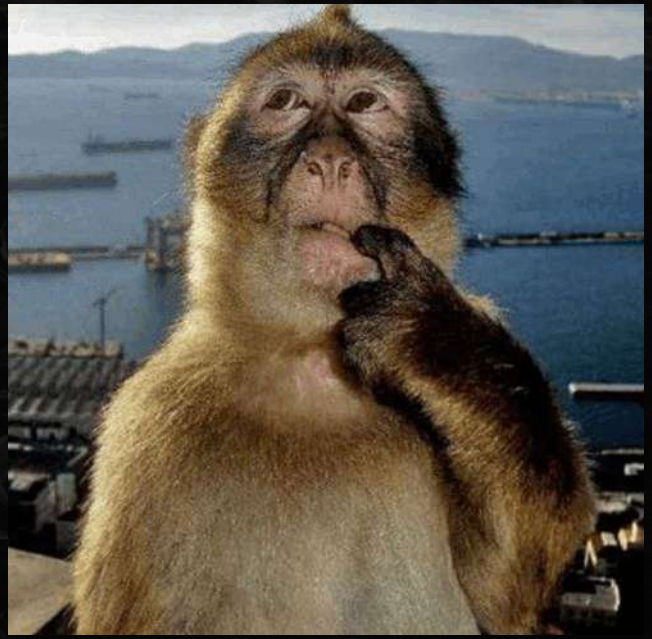
4.205*10^7s EECS experience

niche apple

Summary

- we made walkie-talkie pcbs
- they enable low-latency, long-range, two-way wireless voice communication w/ RF (Real Freakincoolstuff) 😺
- they also have gps and a 6-axis IMU for positional awareness
- everything on-board is displayed on an OLED display

Problem statement:



Motivation:

its cool 😎

Features:

- **STM32L4 MCU** for centralized control (audio, RF, sensors) with SWD debugging
- **Digital audio chain**: microphone input → conditioning → digitization → packetization → reconstruction → speaker amplification
- LoRa 915MHz wireless module with external antenna
  - **Widely used in industry** for IoT applications
- GPS module for real-time location data w/ internal patch antenna
- IMU for motion/orientation sensing
- **Integrated power management**: LiPo battery, buck regulator, and LDO rails
- User interface: onboard display (signal strength, GPS, status), **push-to-talk button**

System architecture

Primary Data Flow

PTT Button
Button

Mic
I²S

STM32
TX Unit

LoRa RF
Long Range Link

STM32
RX Unit

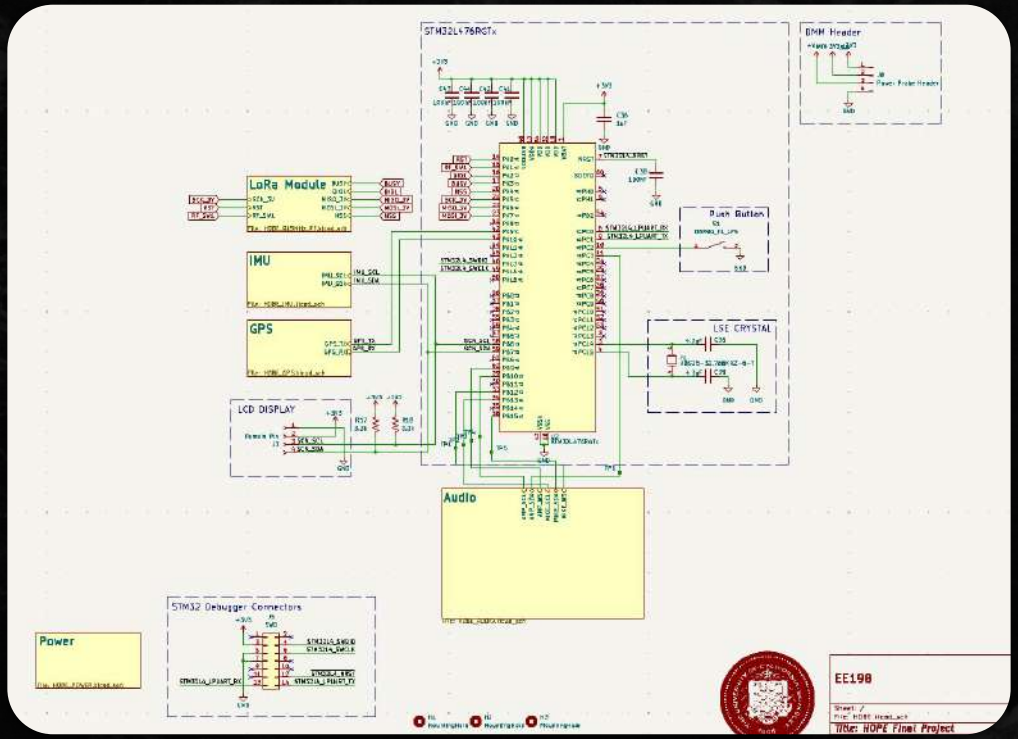
Amp + Speaker
I²S

Secondary Data Flow

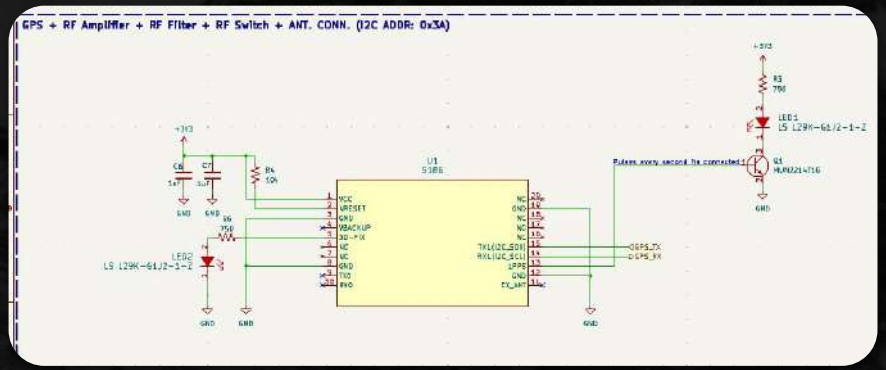
GPS + IMU
UART + I²C

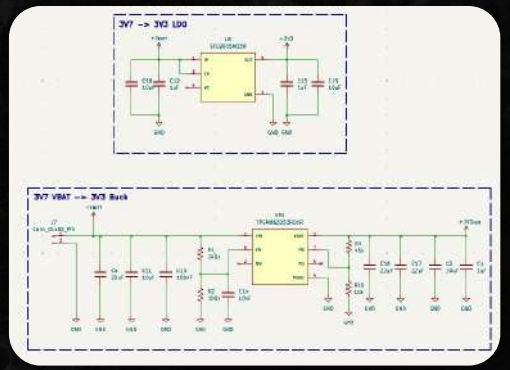
Display
I²C

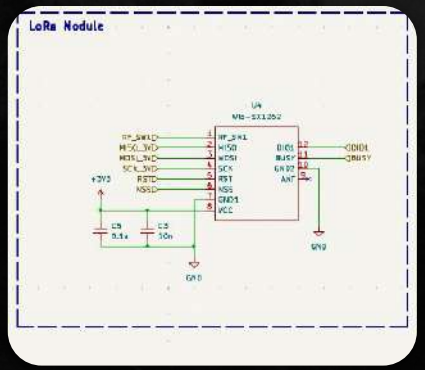
Schematic (full)

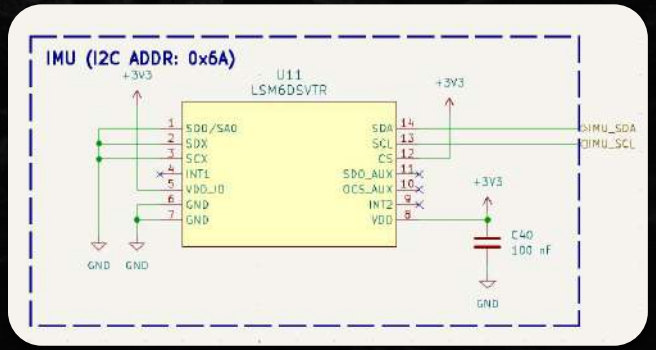


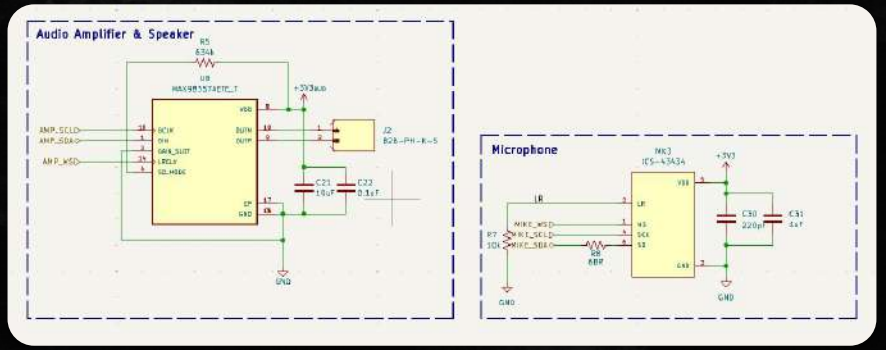
Schematic cont.







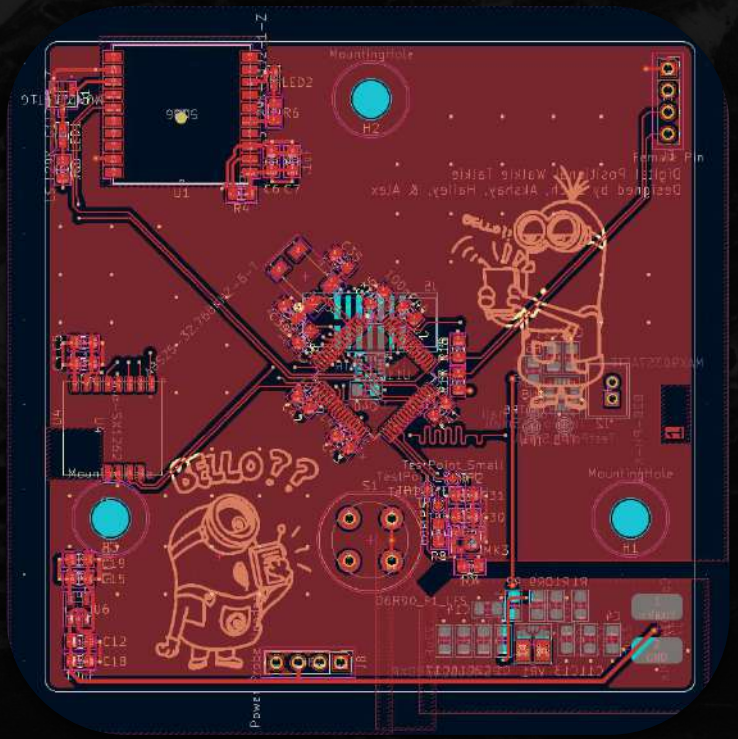




Layout

- 4-layer stackup (signal-gnd-pwr-signal)
- Switching regulator isolation
- Mounting holes for case
- 3.0 x 3.0 in form factor

Layout cont.



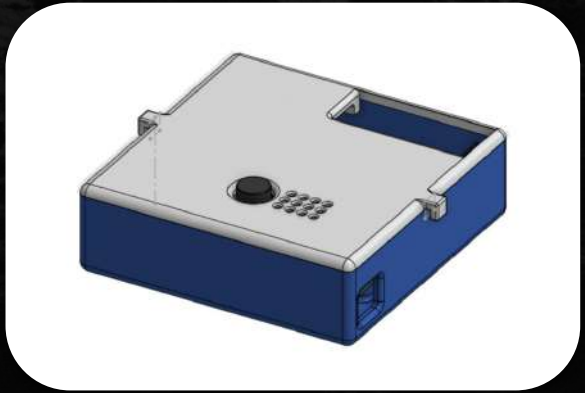
Bill **of materials**

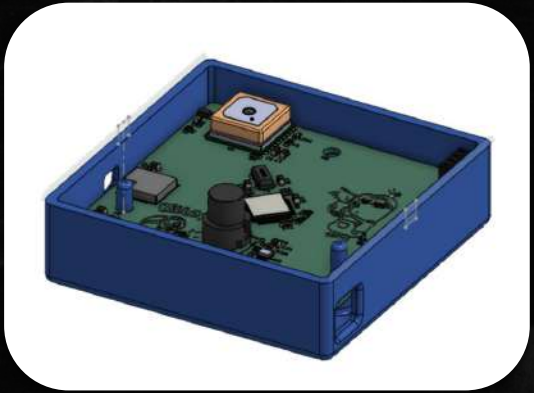
- cost per unit: $89.5 ($88.1 for components, $1.4 per board)

Qty (for 1 board)	Manufacturer Part #	Digi-key Part#/SKU	Mouser Part#/SKU	Price/unit ($)	Purchase URL	Reference Designator	Description (include component value if a	Datasheet Link	Multiple	Total Qty	Total Price/part ($)
											Total Price for Project
											$100.72
1	N/A	N/A		$16.99	https://www.ama		2pcs 3.7V 3000mAh Lithium P	N/A	1	1	$16.99
2	08051A4R3CAT2A	478-10404-1-ND		$0.20	https://www.digi	C35, C39	CAP CER 4.3PF 100V NP0 080	https://datashe	2	4	$0.80
6	CL21B105KBFNNNE	1276-1029-1-ND		$0.08	https://www.digi	C1, C6, C12, C1	1 µF ±10% 50V Ceramic Capac	https://mm.dig	2	12	$0.96
10	CL21B104KBCNNNC	1276-1003-1-ND		$0.08	https://www.digi	C5, C7, C13, C2	0.1 µF ±10% 50V Ceramic Cap	https://mm.dig	2	20	$1.60
1	N/A	N/A		$9.99	https://www.ama	J3	AITRIP 4pcs I2C OLED Display I	N/A	1	1	$9.99
1	3220-14-0300-00	3220-14-0300-00		$1.13	https://www.digi	J5	CONN HEADER SMD 14POS 1.	http://www.cn	2	2	$2.26
1	22284040	WM50014-04-ND		$0.44	https://www.digi	J8	Connector Header Through H	https://www.m	2	2	$0.88
2	RC0805FR-073K3L	311-3.30KCRCT-ND		$0.10	https://www.digi	R17, R18	3.3 kOhms ±1% 0.125W, 1/8W	https://www.ya	2	4	$0.40
1	Y41A00511FPLF5	401-1978-ND		$1.62	https://www.digi	S1	Pushbutton Switch SPST-NO Ki	https://www.ck	2	2	$3.24
1	STM32L476RGTx	497-19382-1-ND		$9.10	https://www.digi	U2	IC MCU 32BIT 1MB FLASH 64L	https://www.st	2	2	$18.20
1	ABS25-32.768KHZ-6-T	535-10240-1-ND		$0.61	https://www.digi	Y1	32.768 kHz ±20ppm Crystal 6p	https://abracor	2	2	$1.22
2	LS L29K-G1J2-1-0-2-R18-Z	475-LSL29K-G1J2-1-0-2-R1		$0.26	https://www.digi	LED1, LED2	Red 630nm LED Indication - Di	https://look.ar	2	4	$1.04
1	MUN2214T1G	MUN2214T1GOSCT-ND		$0.16	https://www.digi	Q1	Pre-Biased Bipolar Transistor (	https://www.or	2	2	$0.32
2	RC0805FR-07750RL	311-750CRCT-ND		$0.10	https://www.digi	R3, R6	750 Ohms ±1% 0.125W, 1/8W	https://www.ya	2	4	$0.40
3	CRCW080510K0FKEA	541-10.0KCCT-ND		$0.10	https://www.digi	R4, R7, R10	10 kOhms ±1% 0.25W, 1/4W C	https://www.vi	2	6	$0.60
5	CL21A106KOQNNNE	1276-1096-1-ND		$0.08	https://www.digi	C2, C11, C18, C	10 µF ±10% 16V Ceramic Capa	https://mm.dig	2	10	$0.80
3	CC0805JRNPO9BN221	311-111S-1-ND		$0.11	https://www.digi	C23, C24, C30	CAP CER 220PF 50V C0G/NPO	https://www.ya	2	6	$0.66
1	B2B-PH-K-S	455-1704-ND		$0.10	https://www.digi	J2	Connector Header Through H	https://www.js	2	2	$0.20
1	ICS-43434	1428-1066-1-ND		$3.27	https://www.digi	MK3	MICROPHONE MEMS DIGITAL	https://invense	2	2	$6.54
1	CRCW0805634KFKEA	541-634KCCT-ND		$0.10	https://www.digi	R5	RES SMD 634K OHM 1% 1/4W	https://www.vi	2	2	$0.20
1	CRCW080568R0FKEAC	541-CRCW080568R0FKEAC		$0.01	https://www.digi	R8	RES 68 OHM 1% 1/8W 0805	https://www.vi	2	2	$0.02
1	MAX98357AETE+T	MAX98357AETE+TCT-ND		$3.19	https://www.digi	U8	Amplifier IC 1-Channel (Mono	https://www.ar	2	2	$6.38
1	LSM6DSVTR	497-LSM6DSVTRCT-ND		$3.74	https://www.digi	U11	INEMO INERTIAL MODULE: 3D	https://www.st	2	2	$7.48
2	CL21B103KBANNNC	1276-1015-1-ND		$0.08	https://www.digi	C3, C14	10000 pF ±10% 50V Ceramic C	https://www.sa	2	4	$0.32
1	114993390	1597-114993390CT-ND		$5.95	https://www.digi	U4	General ISM < 1GHz LoRa™ , L	https://www.se	2	2	$11.90
3	CL21A226MAYNNNE	1276-CL21A226MAYNNNE(		$0.08	https://www.digi	C4, C16, C17	CAP CER 22UF 25V X5R 0805	https://mm.dig	2	6	$0.48
1	RK73H2ATTD2403F	2019-RK73H2ATTD2403FC1		$0.10	https://www.digi	R1	240 kOhms ±1% 0.25W, 1/4W	https://www.ko	2	2	$0.20
1	RC0805FR-07100KL	311-100KCRCT-ND		$0.10	https://www.digi	R2	100k Ohms ±1% 0.125W, 1/8W	https://www.ya	2	2	$0.20
1	CRCW080544K2FKEA	541-44.2KCCT-ND		$0.10	https://www.digi	R9	44.2 kOhms ±1% 0.25W, 1/4W	https://www.vi	2	2	$0.20
1	STLQ015M33R	497-15934-1-ND		$0.49	https://www.digi	U6	Linear Voltage Regulator IC Po	https://www.st	2	2	$0.98
1	TPSM863253RDXR	296-TPSM863253RDXRCT-I		$2.63	https://www.digi	VR1	Non-Isolated PoL Module DC I	https://www.ti	2	2	$5

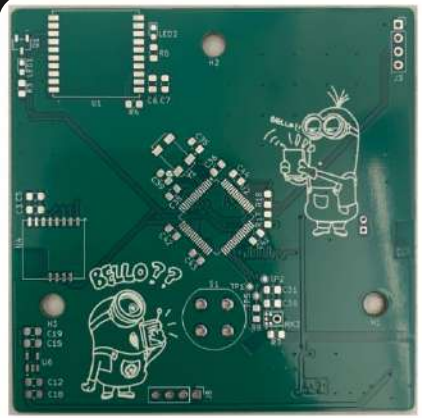
Mechanical design

- Designed w/ Onshape
- 3D printed w/ PLA
- Tolerances tuned for tight fit
- Openings for mic, antenna, battery, speaker





Bring-up



unsoldered boards

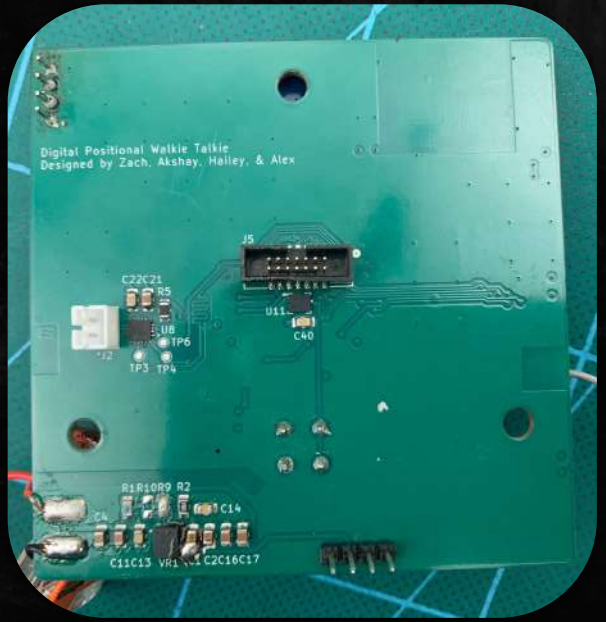
used a stencil for SMT components (ignore the handsome guy)

we baked the boards in the reflow oven until they were golden brown

we hand-soldered the through-holes

Bring-up


3000mAh
3.7V
11.1Wh
Lithium Rechargeable Battery
MakerFocus
HELLO??


Digital Positional Walkie Talkie
Designed by Zach, Akshay, Hailey, & Alex
J5
C22C21
R5
U8
TP6
TP3
TP4
U11
C40
R1R10R9 R2
C14
C11C13
C2C16C17

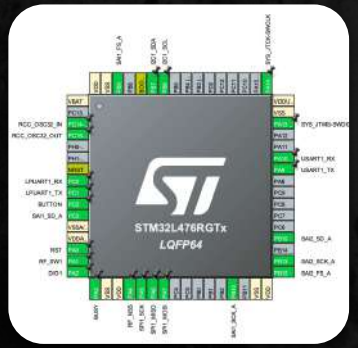
Debugging

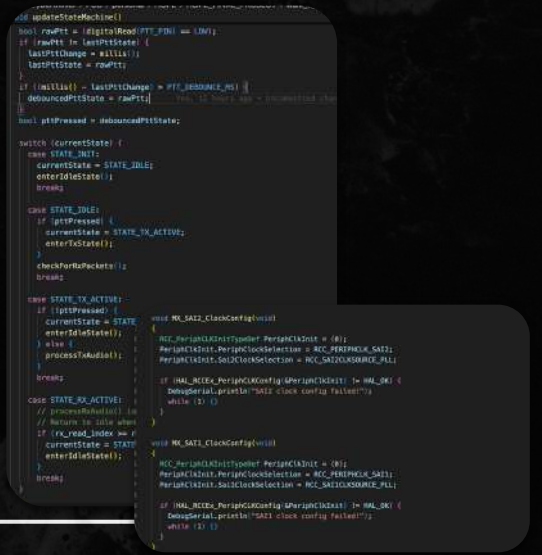
- Could not upload code to stm32 → figured out that our debug header 3.3V was not connected to pad
- Components shifted during reflow oven → had to use heat gun to fix
- For stm32l476rgtx there are no native arduino i2s libraries - had to make our own



Programming

- C++ program includes
  - I^2C/SPI/I^2S interfaces for Mic, IMU, GPS, LoRa, STM32, Screen, Audio
  - Custom I^2S library for specific STM32 module
  - Compression algorithm for data transmission between boards (***μ***-Law)
  - Push-to-talk to switch between RX/TX modes





Making it sound right

- MEMs mic configuration and gain tuning
- Digital audio handling over I2S
- Amplifier and speaker matching

DEMO

100+ (wo)man-hours spent

200+ traces routed

122 components soldered

80,000+ bits transmitted + received wirelessly

Conclusion

- It was very difficult and complicated and we struggled...
- But it was very fun
- We are grateful to Berkeley IEEE & HOPE Staff for this opportunity
- Thanks for listening and bearing 🐻 with us 👬

THANK YOU!!