MegaSat Hardware Kit

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What is the MegaSat?

The MegaSat is a microprocessor developmental board designed to assist students in learning electronic instrumentation and programming using the Arduino Mega.

It was developed by the Louisiana Space Grant Consortium as a replacement for the BalloonSat developmental board.

From BalloonSat to MegaSat

- BalloonSat was developed in the early 2000s at LSU by S.B. Ellison and Jim Giammanco

- The BalloonSat featured a Basic Stamp microcontroller
  - 20 MHz
  - 38 Bytes RAM!
  - 61 PBASIC commands

- 64 Kb EEPROM (2LC64) on I2C

- RTC (DS1302)

- 4 Channel 8 Bit ADC0384

- The BalloonSat was used by the ACES program for over ten years before the MegaSat was created to update the hardware.
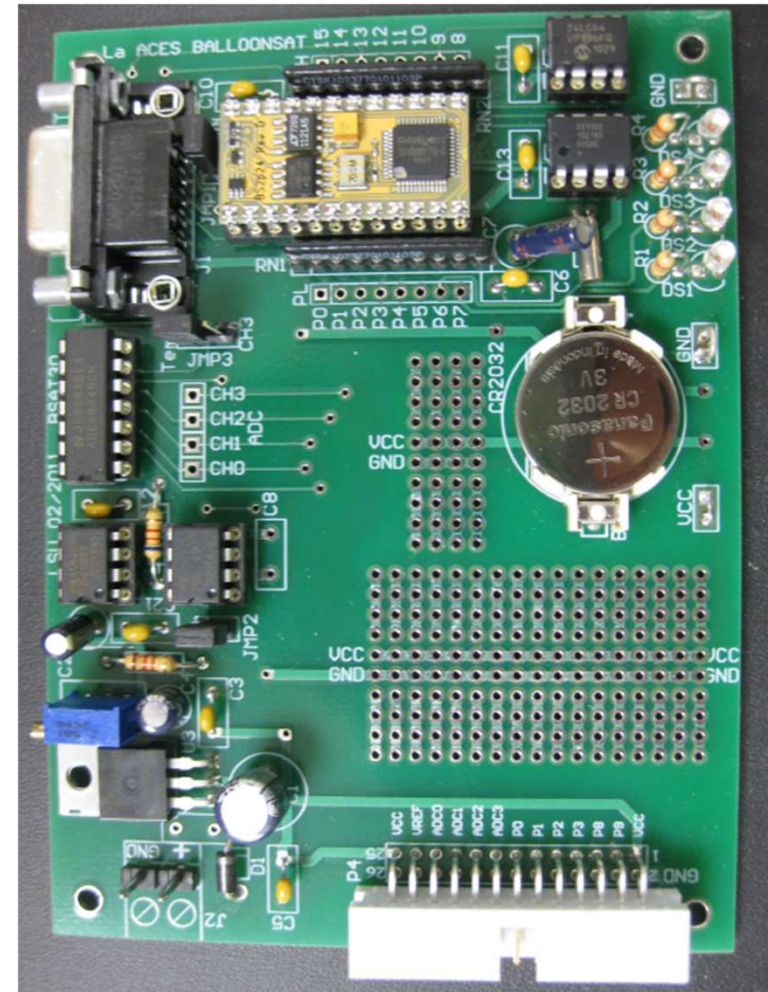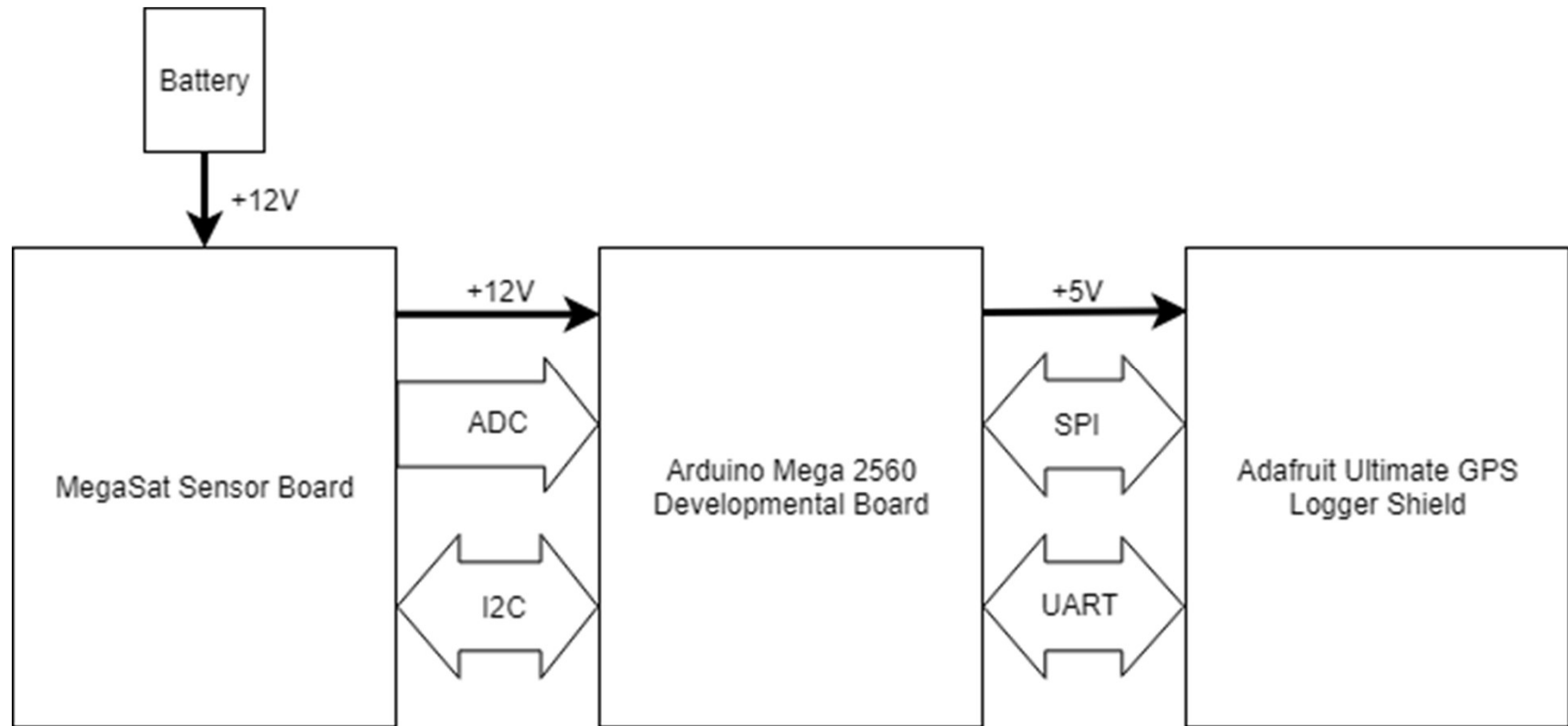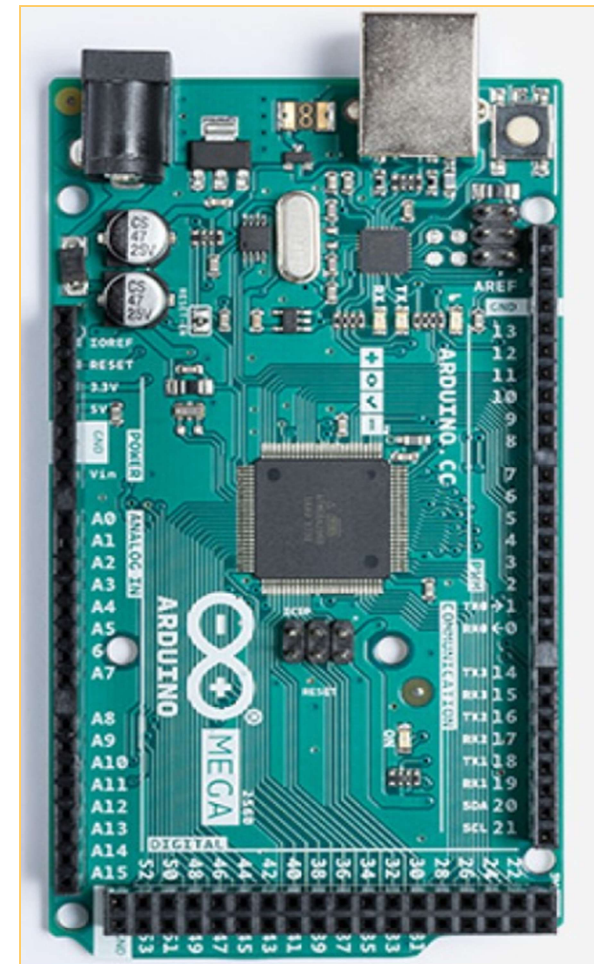

BalloonSat

Major Components
MegaSat Kit

Arduino Mega2560

- 16 MHz ATmega2560 Microcontroller
- 256 KB Flash Memory (Program Space)
- 8 KB SRAM (Variable Space)
- 4 KB EEPROM

Arduino Mega Development Board

Arduino I/O

- Communication with the Mega is achieved using stackable header pins that connect to the internal circuitry of the board.

- Header Pins provide easy access to:
  - Power Inputs/Outputs
  - Analog-to-Digital (ADC) Channels
  - Digital I/O Pins
  - Serial Channels

- Standard footprint with commercially available expansion boards (Shields)
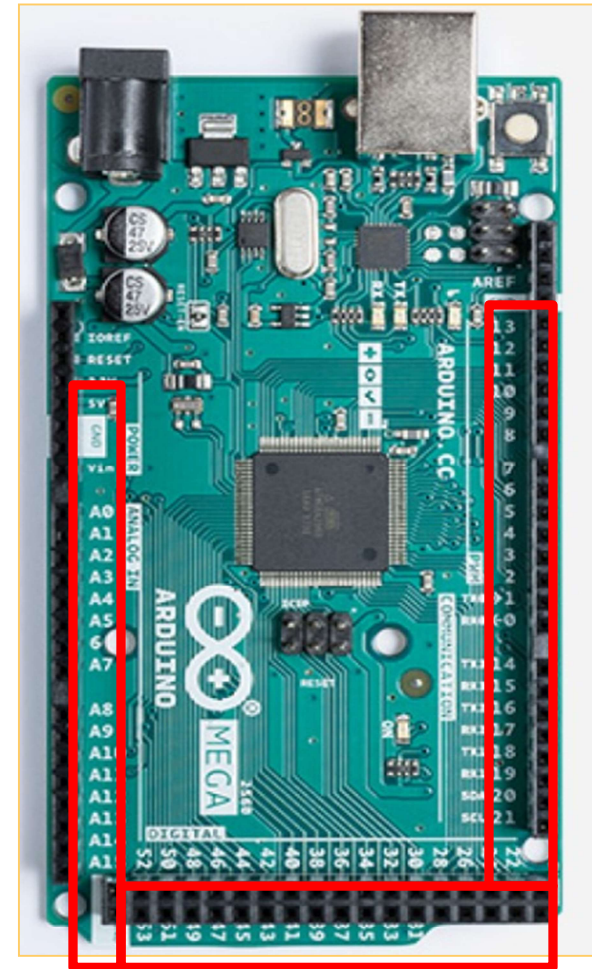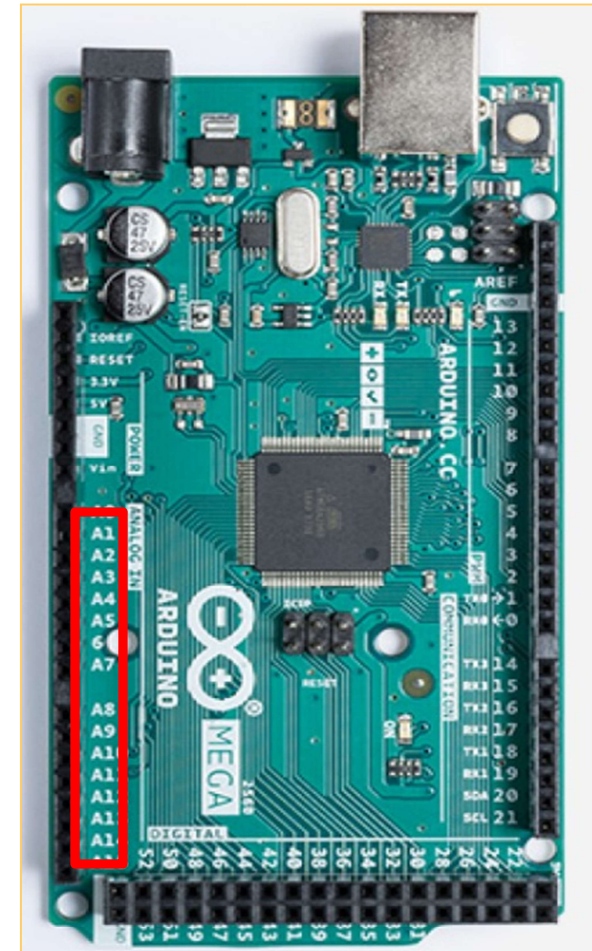

Arduino Mega header pins

ADC Channels

- The Mega provides sixteen 5V ADC channels for collecting information from external devices
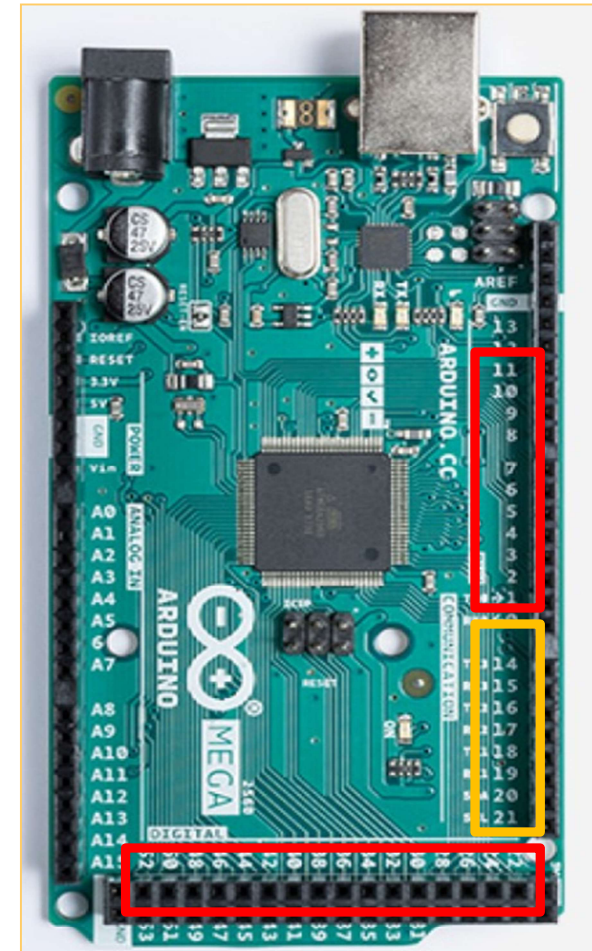- 10 bit (1024) resolution

Arduino Mega Analog Pins

Digital Input/Output

- The Mega provides 54 digital input/output (I/O) channels
- Four hardware serial (UART) TX/RX pairs
- SPI is available for MISO, MOSI, SCK and CS using the SPI library
- 5V I^2C up to 400 KHz
- 15 PWM pins which provide an 8-bit "Analog" output (Not true analog)


Arduino Mega Digital Pins

Programming Changes

- Change from BASIC based programming language to C++ based

- Enables use of libraries, functions, user defined data structures

- Use Arduino IDE with built in library manager

Adafruit Ultimate GPS Logger Shield

- This is the Arduino Ultimate GPS Logger Shield. It comes with
  - microSD socket
  - Internal antenna and connector for external antenna
  - GPS unit
  - Prototyping Area
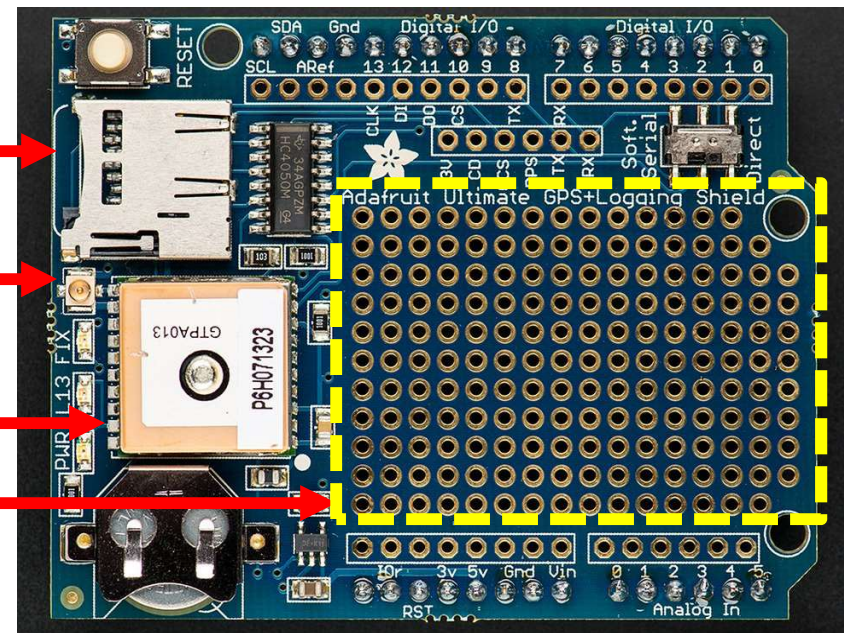
GPS Software Serial

- Adafruit shield "Hardware" connect to same UART as programming port

- Mega has additional 3 Additional hardware UARTs

- Use Jumper to connect to Serial1 to Software Serial Pins of the GPS unit
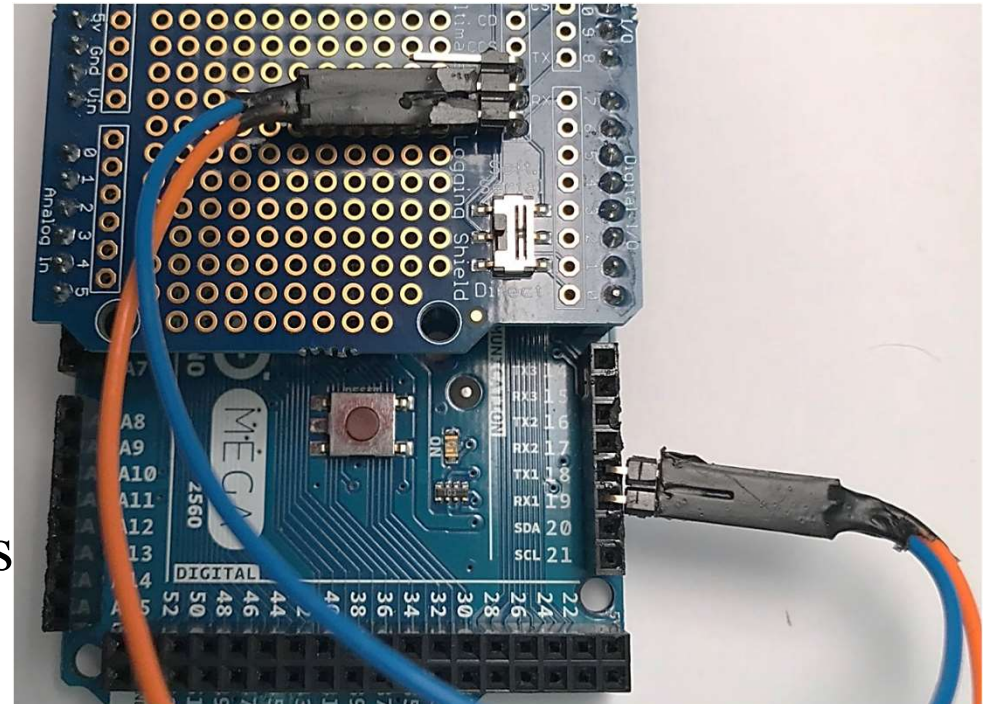
MegaSat Shield

- The MegaSat includes several components for students to utilize:
  - Arduino Mega Interface
  - Real Time Clock
  - Gyroscope / Accelerometer
  - Pressure, Temperature and humidity sensor
- MegaSat powers all components on the board and the Arduino a +12V supplied externally to the board (Does include bias protection)
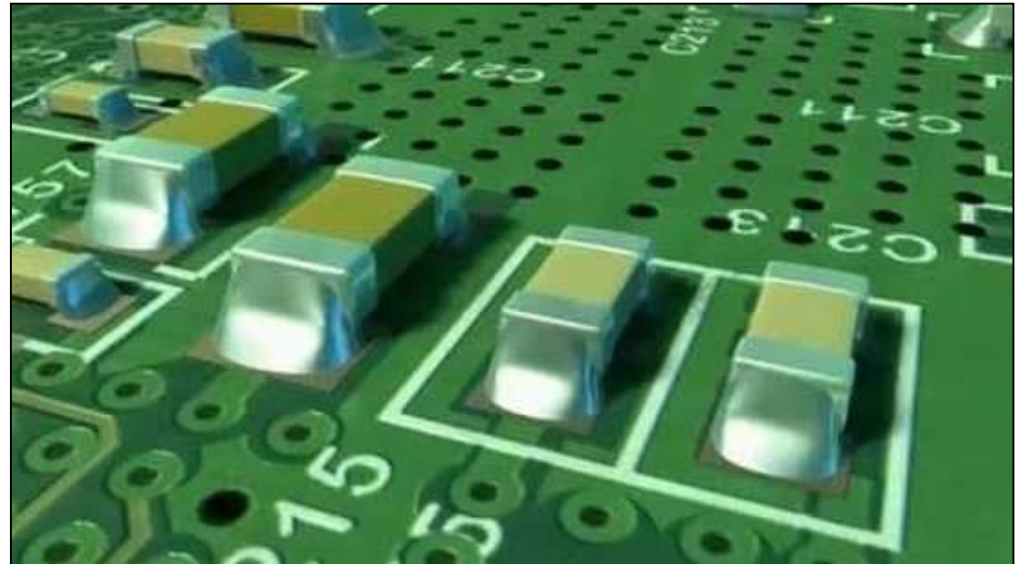- 4.5 x 5.5 inches
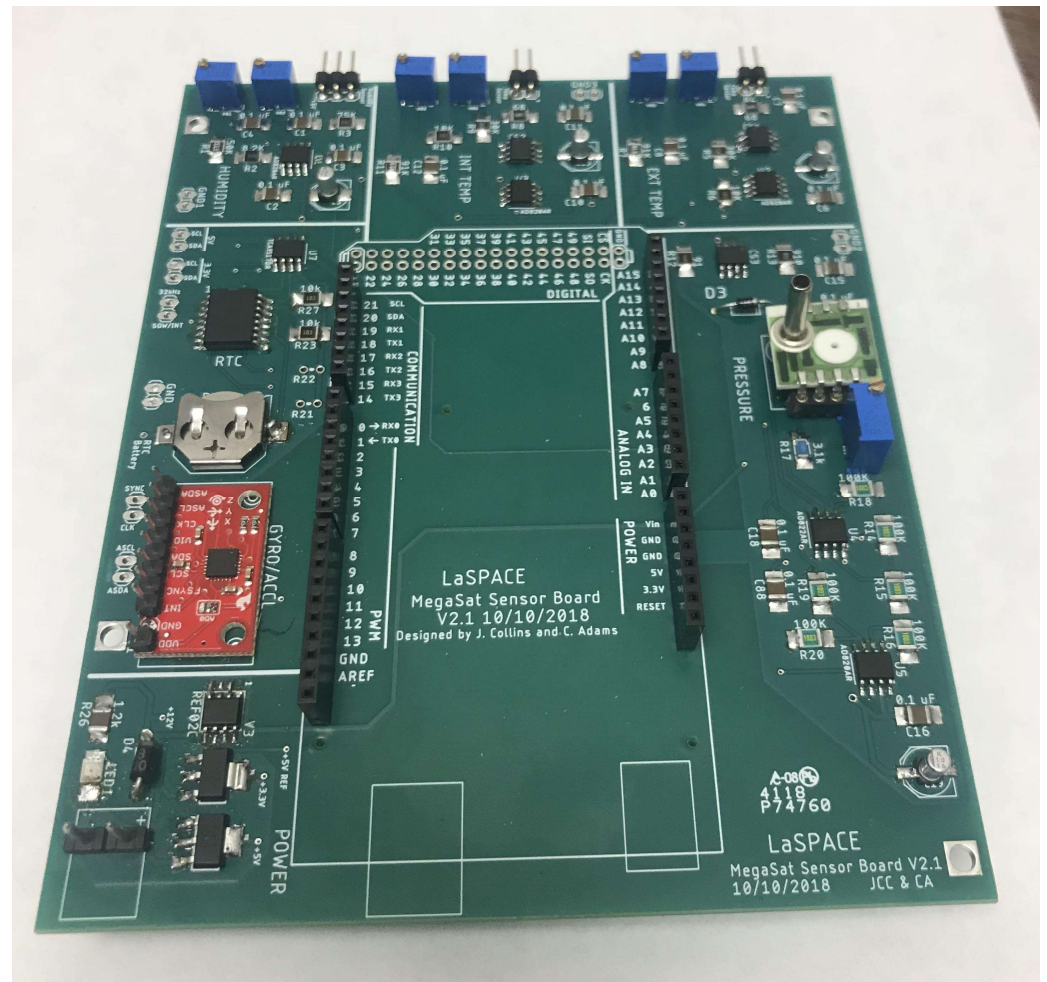
MegaSat Assembly

- Large number of surface mount components

- Still Capable of being soldered with standard soldering iron

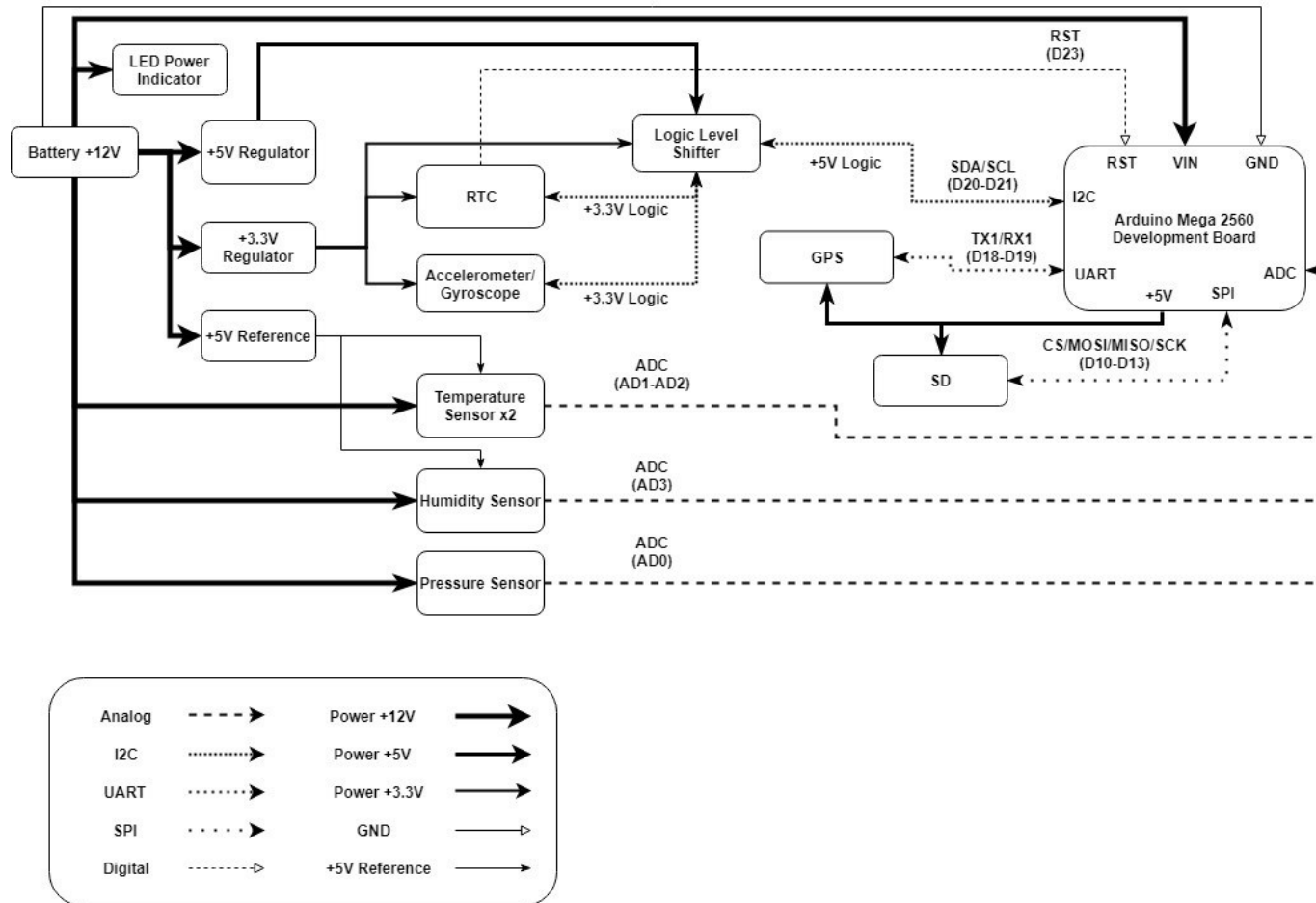- SMD Solder practice kit early in the second semester

  https://laspace.lsu.edu/laaces/wp-content/uploads/2020/08/A27.02_SMD_Soldering_Techniques.pdf
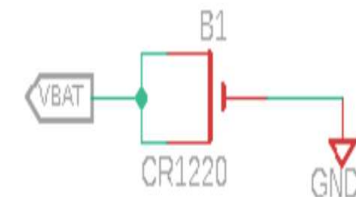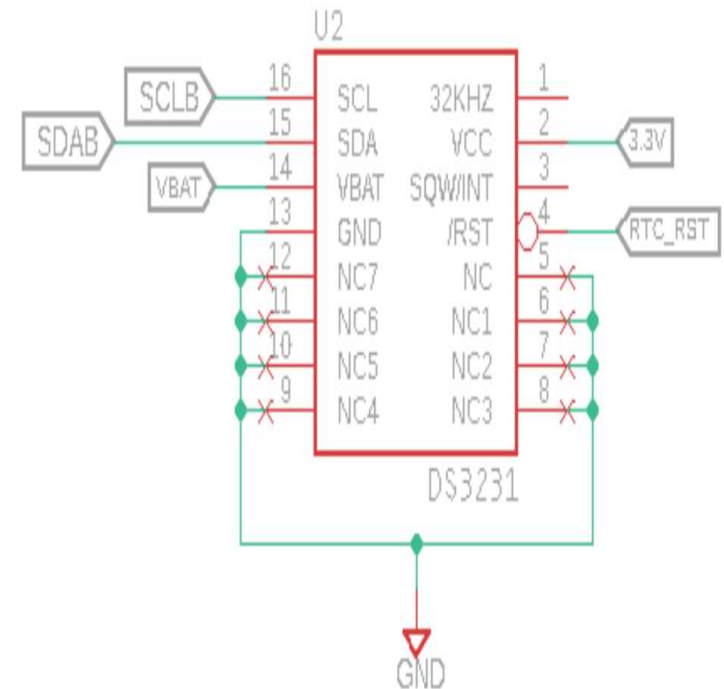
MegaSat Shield Components

Real-Time Clock

- Maxim Integrated DS3231 RTC

- Fast (400kHz) serial I2C interface

- Provide stable timestamp in event of no GPS fix

- Arduino clock based timing has observable drift and can be affect by interrupts.
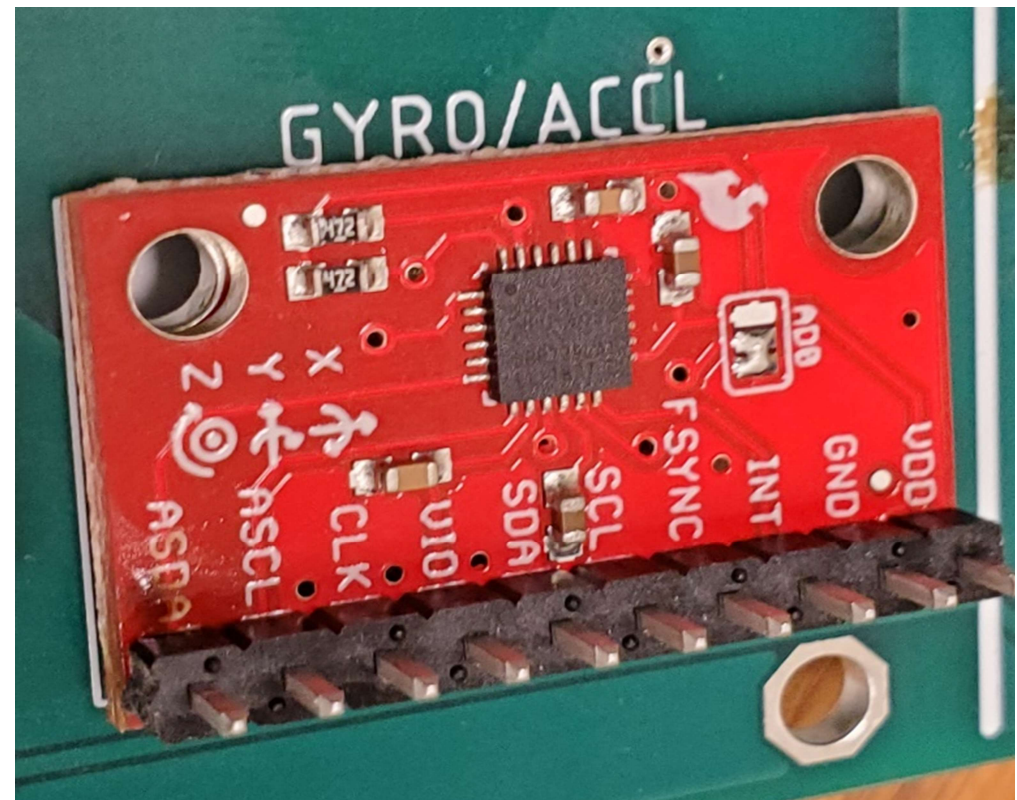
Gyroscope/Accelerometer

- InvenSense MPU-6050 gyroscope/accelerometer

- Programmable tri-axis angular rate sensor (gyro) with full-scale range of ±250, ±500, ±1000, and ±2000 degrees per second

- Programmable tri-axis accelerometer with a full scale range of ±2g, ±4g, ±8g and ±16g

- Readout via I^{2}C

- Has address conflict with RTC corrected by AD0 jumper

Environmental Sensors

- 2x 1N457 diodes temperature Sensors

- Honeywell HIH-4000-003 Humidity Sensor

- ICS-1230 Pressure Sensor

- MegaSat has adjustable amplifying circuit to allow full 0-5V range of ADC

- Kit includes the connectors for remote mounting the temperature and humidity sensors
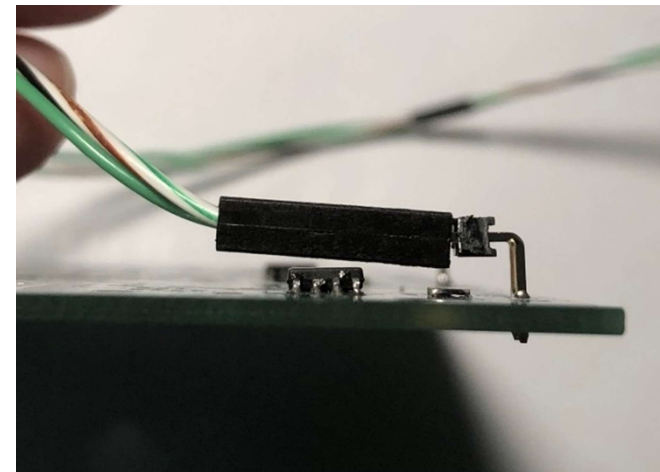
Expansion Capabilities

- Existing commercial Arduino shields can be added to the MegaSat including Protoshields for custom circuits

- Be careful of pin conflict

Used Pins	Usage
D 18,19	Serial1 GPS UART
A 0,1,2,3	Temperature, Pressure Humidity Analog In
D 10,11,12,13	SD Card SPI
D 20, 21	I^2C (IMU and RTC)
D 7, 8	GPS software Serial Pins