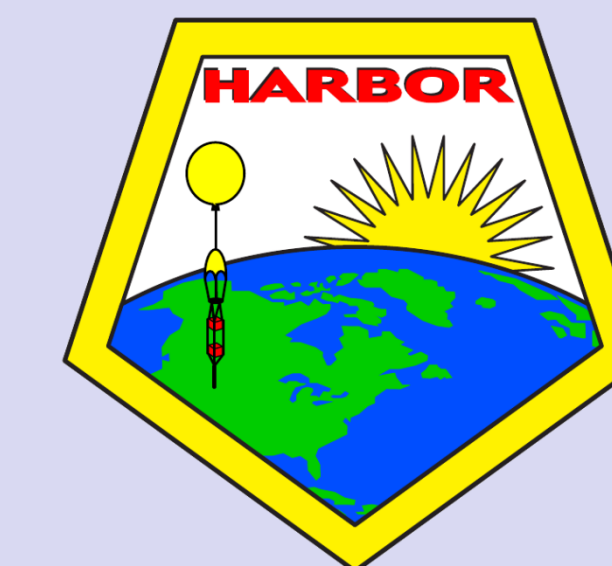




# A Multi-Sensor Array to study flight dynamics, atmospheric pollution and gas composition in Earth's atmosphere



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## Abstract

High altitude weather balloons are a valuable tool in understanding Earth's climate and weather systems. However, a shortage of data exists for gas compositions and pollution levels at altitudes attainable by weather balloons; most aircraft fly far below them and spacecraft orbit high above them. Weight and price are two major constraints when selecting scientific instruments to fly onboard weather balloons. Until recently, these factors have limited the quantity and variety of science achievable with weather balloon systems. Advances in technology are making it possible to fly circuitry capable of filling the gap in atmospheric data. Our team has surveyed the market for sophisticated, affordable, and lightweight electronic devices needed to build the next generation of scientific instruments for gathering data at the edge of space and from the polluted zones above Utah's metropolitan areas. Our mission is to increase the capabilities of our current Multi-Sensor Array (MSA v3) which consists of accelerometers, magnetometers, temperature sensors, and pressure sensors. The new system will support an expandable array of particulate and gas sensors; with added radio telemetry capabilities and simpler user interface.

## Design/Concept

The MSA v4 will consist of three add-on boards and a Raspberry Pi (RPi) single board computer (Figure 5). The main add-on board will feature sensors which will monitor atmospheric conditions from inside of the MSA enclosure and will connect directly to the raspberry pi. The external board and user interface board will be extensions of the add-on board and will be placed outside of the enclosure to monitor external atmospheric conditions and provide easy access to the user.

We have chosen to use the RPi, because it is an inexpensive alternative to creating our own embedded system. The RPi is lightweight (40g) and is easily programmed using higher level languages like Python inside a Linux OS. The RPi is easily expandable featuring 26 General Purpose Input/Output (GPIO) pins capable of I2C, UART, and SPI interface protocols.

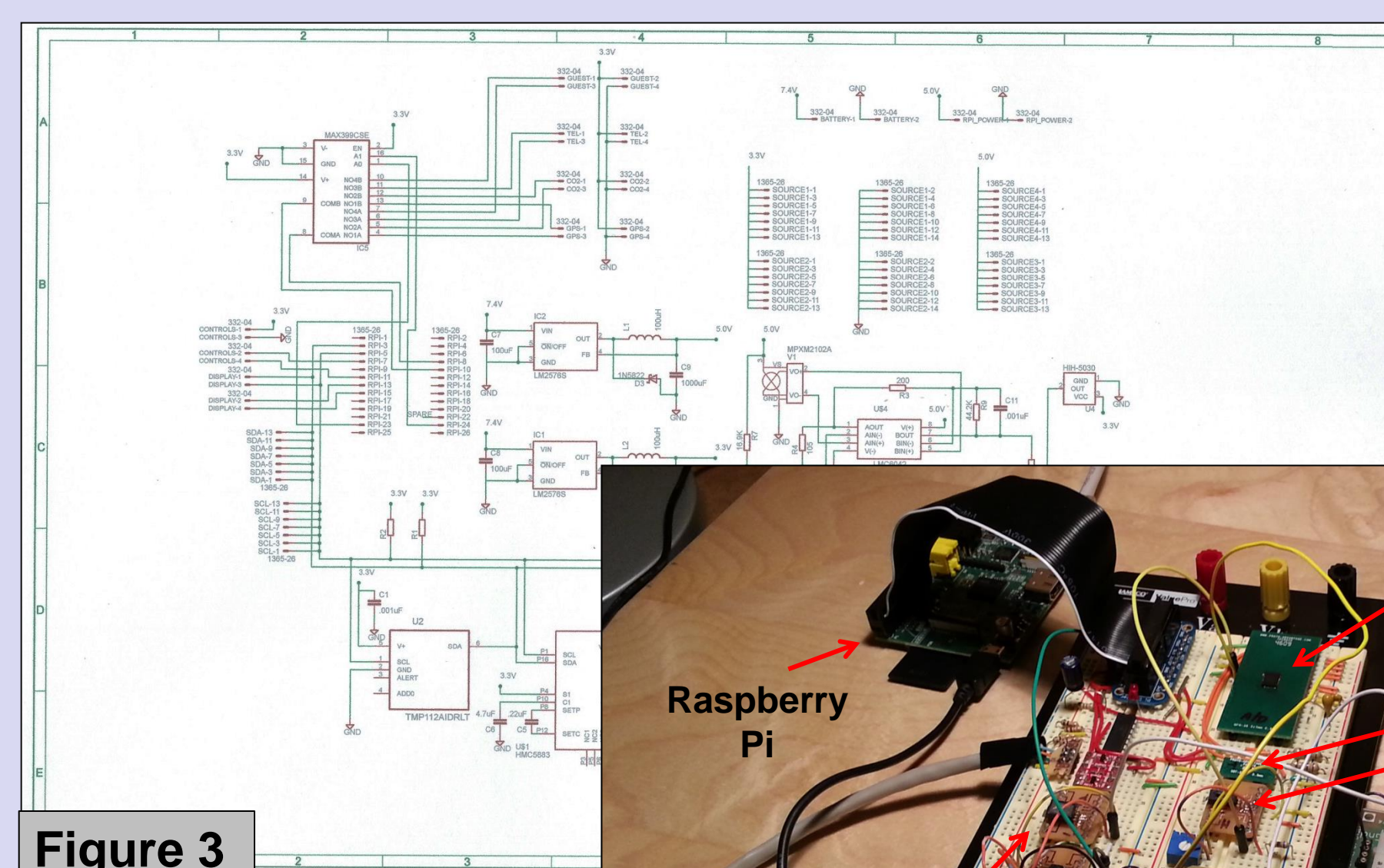


Figure 3

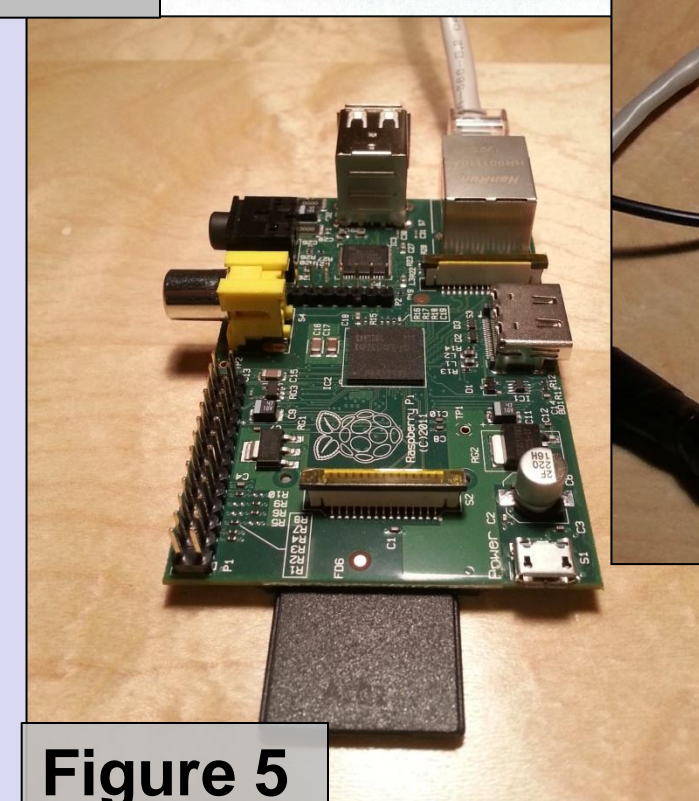


Figure 5

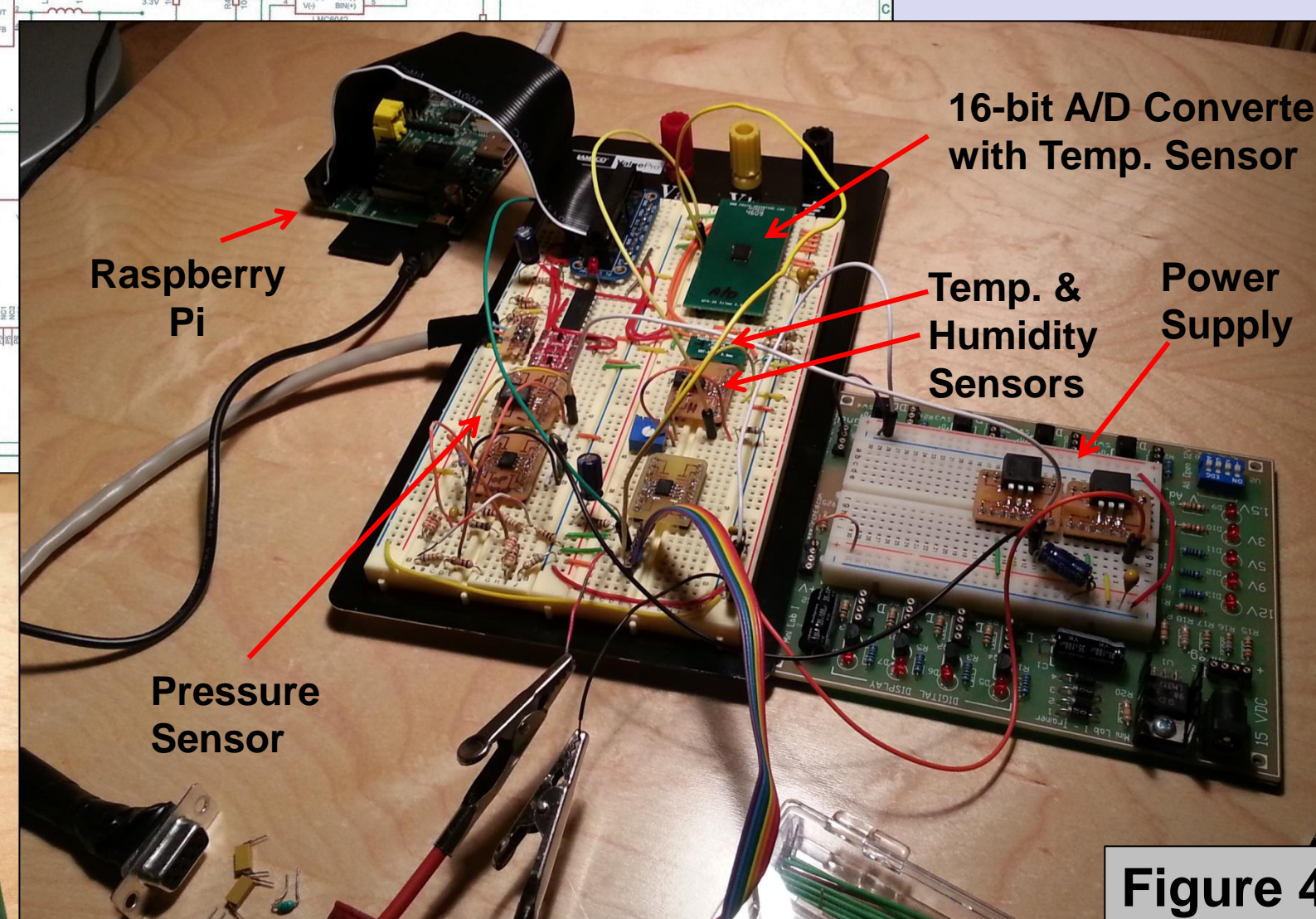


Figure 4: Current set-up to test chips and sensors  
Figure 5: The Raspberry Pi single board computer

## Current Progress

We have currently built most of the critical systems on development boards and have begun testing and calibrating all of the sensors. We have gathered working data from an HIH-5030 humidity sensor (Figure 2), the on-chip temperature sensor of a LTC2495 16-bit A/D converter (Figure 1), and a TMP112 temperature sensor via the I2C bus. Additionally, we have successfully received GPS and CO2 data via the UART on the Raspberry Pi. Preliminary data has also been gathered from an optical dust sensor, which needs further calibration. We have begun writing and debugging the necessary programs in C for reading the sensors, converting the data into meaningful information, and storing data.

## Future Testing

We will soon be using the HARBOR environmental test facility to simulate flights to the edge of space for both hardware preflight certification and for sensor calibration. The MSA system must operate at pressures as low as 1 mbar and temperatures as low as -50° Celsius, which are typical conditions from the upper troposphere (10-12 km) to the lower stratosphere (30-34 km). The 2013 flight season will begin in mid-April allowing for the operational flight testing of this new version of the MSA system.

## Conclusion

This newest version of the Multi-Sensor Array (version 4) will be flight-tested side-by-side with the existing MSA (version 3). Once it passes flight tests, version 4 will allow for substantially improved flexibility and data collecting power. Version 4 will form the base flight platform for all HARBOR flights providing improved measurements of Earth's atmosphere. These data will aid our understanding of issues such as metropolitan inversions and global climate change.

## Acknowledgements

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