# Background

The prototype Walker Stalker has been assembled and is ready for field testing. We need to make sure the operating procedures and conditions can operate on a long-term basis.

# Aim

* Assess whether or not the walker stalker is suitable for deployment in its current configuration
* Assess sensor performance in real operating conditions over an extended amount of time (1 week)

# Method

## Hardware Overview

|  |  |
| --- | --- |
| Microcontroller | Seeeduino Stalker v2.3 |
|  |  |
| Battery | 980 mAh Lithium Polymer |
|  |  |
| Solar Panel | 0.5W Mono-crystalline |
|  |  |
| Air Temperature | DS18B20 |
|  |  |
| Case Temperature | DS3231 (Dallas Semiconductor) |
|  |  |
| Wall temperature | DS18B20 |
|  | TMP006 |
|  |  |
| Relative Humidity | RHT03 |
|  | HTU21D |
|  | SHT15 |
|  |  |
| Luminosity | TSL2561 |
|  | BH1750FVI |
|  | Light-Dependant Resistor |
|  |  |
| Sound Level | Freetronics Mic[[1]](#footnote-1) |

* The microphone was connected to the controller, but not sampled due to limited program space
* The sensor module also includes the option of adding a current sensor. This was not connected or sampled on the prototype due to limited program space

## Code

* The controller, XBee, and SD card are set to sleep for most of the deployment
  + Every 10 minutes, the system wakes up to record a sample and writes it to a 2GB SD card
  + During this time, the XBee sends a status update to the coordinator
    - The XBee needs at least 1 second to wake – we’re giving it 2 seconds
    - There’s much greater success sending two status packets with a short delay compared to sending a single packet
  + After the packet is finished, the system goes back to sleep
  + In a full deployment, the system would normally stay awake for 30 seconds to ensure the packet propagates through the network
    - Could not be implemented due to space
* The XBee is running in transparent configuration for this stage
  + Later stages would require API mode for mesh networking
  + Not enough space at the moment
  + The status packet contains a timestamp, battery level, and internal case temperature
    - Sending the full sample packet is not possible due to program size constraints on the chip
* Sound level sensing and current consumption sensing have been disabled for this test due to program size restrictions
  + The sound sensor will still be connected to keep the same level of current draw to get a more realistic deployment current consumption

## Enclosure

* The microcontroller, battery, majority of the sensors are mounted inside an IP65 ABS enclosure with an acrylic window
  + The enclosure was mounted flat, with its window facing upwards
* The solar panel was taped to the inside of the acrylic window
  + The panel receives the most amount of sun in this position (arguable)
  + Keeping the panel inside the case protects it against rain
* Light sensors were placed in a horizontal position
  + The sensors are intended to measure the ambient light level
  + Facing them upwards would only measure the incident solar illumination
  + All sensors were placed flat against the inside of the acrylic, next to each other to receive the same amount of light
* DS18B20 temperature sensors were coated with 5-minute epoxy and painted white to measure the surrounding temperature
  + The sensors are black, which would absorb heat from the sun and get hotter than the surroundings

* For surface temperature, an external DS18B20 sensor was placed on top of gravel
  + The TMP006 sensors was mounted inside the enclosure, pointed horizontally at the same patch of gravel
* Several sensors have been mounted on the outside of the enclosure
  + To measure relative humidity and air temperature, the sensors need to be in actual outside air
  + This means that the sensors and connections must be waterproofed to protect the electronics
* The three humidity sensors, and one of the temperature sensors are mounted in a ventilated weather screen
  + Sensors were zip-tied to a cup to keep them high and dry inside another plastic container
  + The inside of the plastic container was painted white to keep the internal temperature more consistent with the air temperature
* White foam was placed inside the waterproof enclosure to keep sensors and the solar panel in place
  + The foam also serves to reflect heat from the sun and keep the internal case temperature down for better operation

## Test Conditions/Location

* The enclosure was secured to a steel block on the roof of building 17 at JCU
  + The area gets a good breeze and is exposed to the rain
  + Testing area is locked and has strict key access
* Zip ties were used to ensure the main enclosure and weather housing did not move or tip over
  + The case had its window facing directly upwards
* The coordinator is not kept in a permanent range
  + The coordinator is connected to a laptop computer that needs to be brought within range of the sensor module to receive the status message
  + Occasional transmissions will be received to ensure the module is still running
* The sensor module will be left in-situ, unattended for 7 days
  + At the end of the test, the sampled data will be analysed to ensure the data is accurate
  + Internal case temperatures will be analysed to check that enclosure is operating as per usual
* The status of the sensor module will be checked occasionally via XBee radio to ensure that the system is still running
  + If several status messages are missed, the test will be aborted

# Results

## Code

* Program space is limited to 31.5 KB of space
  + This was not enough to run all of the sensors
  + The code for sampling the microphone and current sensor had to be removed
  + Status packets needed to be severely cut down from sending all sensor readings

## Case Conditions

* During deployment, the internal case temperature reached a maximum of 52.47°C
* Battery levels stayed above 80%
  + Charging with the solar panel took an average of 3 hours
  + Charging also occurred in the morning, when sunlight is hitting the panel directly
* All internal sensors fit inside the enclosure with lots of left over room

## Sensor Performance

* DS18B20
  + The air sensor gave mostly reasonable measurements
  + Temperatures during the day reached over 40°C, which is much higher than the actual temperatures
    - Unreasonably high temperatures were only recorded during the day compared to weather station (A max of 30.1°C recorded by BOM)
    - Night temperatures are reasonable according to the BOM (A min of 19.1°C)
  + Surface measurement was unsuccessful
    - The software took both air and surface temperature samples from the sensor mounted in the weather box
* TMP006
  + The sensor gave the same value throughout the deployment, indicative of an error
  + Even without the errors, the sensor would not have been able to measure the surface temperature through the acrylic casing
* Light sensors
  + Both the TSL2561 and the BH1750FVI produced expected light level outputs and were very similar to each other
  + There are several dips in the light levels throughout the day levels
  + The light-dependant resistor produced light values mostly consisting of 0 or 1023, its maximum possible value.
    - Very little resolution was provided
    - The readings went from 0 to maximum in only 40 minutes and showed no changed when the other light sensors detected a drop in light levels
* Humidity sensors
  + All three sensors produced reasonably similar values
  + The RHT03 sensor had higher peaks at night, compared to the other sensors
  + The SHT15 had lower readings during the day than the other two (up to 10%) lower than the other two sensors
    - Low readings occurred every morning and were not present after midday

# Discussion

## Code

* Steps to reduce program size:
  + Get rid of sensors
    - At the moment, there are many sensors recording the same metrics for performance analysis
    - A real deployment does not need more than one sensor of each type
    - Removing the redundant sensors also removes the libraries used to operate them
  + Apply data reduction
    - Transmitting data over XBee and recording to the SD card are currently performed as separate steps
    - The data is processed and written twice, rather than processing once and writing the data to the two mediums
    - Data is also in its readable form
      * Raw data requires less processing and occupies a smaller number of bytes

* + Do not use SD card to record information
    - SD card libraries occupy a large area of the program space
    - The SD card is used as a backup of the data
    - Data should be transmitted to the network coordinator and stored
    - There is no physical access to the SD card under normal circumstances
* The current solar/battery configuration is suitable for long-term deployment
  + The module needs a minimum of 3 hours of sunlight a day to remain functional
    - This minimum may be less when direct sunlight is considered, rather than the morning sun
  + Assuming a linear battery discharge, the sensor module will last approximately 4 days without charge

## Case

* The maximum temperature inside the enclosure was relatively high, but well within the operating limits of the internal sensors
  + Internal temperatures may be reduced by painting the enclosure white
* The case is large for this application and should be replaced with a smaller enclosure
  + Otherwise, the case and arrangement are acceptable for outdoor deployment of the sensor modules.

## Sensor Performance

* The DS18B20s addresses have since been corrected in the code
  + The air temperature data was higher than the actual ambient temperature
  + The weather housing requires better shading and ventilation to provide more accurate readings
* The TMP006 sensor should be mounted external to the case
  + The reading angle of the TMP006 sensor is also 180°
  + Investigation has showed that the errors were caused by using an incorrect i2c address in the software
* Light sensors
  + Light levels detected by the TSL251 and the BH1750FVI were consistently similar for the duration of the deployment
  + Either sensor would be suitable for the sensor module
  + The LDR is unusable as an outdoor light level sensor due to the lack of resolution that it provides
* Humidity sensors
  + The SHT15 deviated from the other two sensors rather significantly
  + The change may be a result of a faster response time, but this is unlikely.
    - Short spikes in humidity are recorded by all sensors at the same time, yet the SHT15 values are still significantly lower (up to 10%RH) than the other two sensors
  + Relative humidity is subjective to the temperature of the sensor
    - All of the sensors were placed in close proximity to each other
    - Some sensors may have received more sun compared to the others
    - Sensors may have been in the shade of the weather housing

# Conclusion

* Code changes need to be made for full functionality in the sensor module
* The chosen enclosure comfortably fit all internal sensors with room to spare
  + A smaller enclosure should be used
  + Temperatures inside the enclosure were acceptable, but could be reduced by painting
* Several sensors encountered problems
  + The TMP006 sensor needs to be mounted outside the case and be appropriately addressed in the software
  + The DS18B20 sensor requires proper addressing, and the weather housing would benefit from shading or ventilation
  + The LDR did not produce usable results and should be removed
  + Both TS2561 and BH1750 sensors produced reasonable and very similar results
    - Either one of the sensors should be used further, but using both results in redundant sensors and a waste of program space
  + The SHT15 humidity sensor produced significantly different results that can possibly be attributed to differences in temperature between the sensors
* Overall, the sensor module performed reasonably well and consistently over the deployment timeframe
  + Battery and solar capacity are sustainable if 3 hours so long as the module receives 3 hours of sunlight a day
  + However, there are several fixes that need to be applied to the sensors
  + Program size also needs to be reduced for full functionality

1. Microphone was connected to the controller, but not sampled due to program space limitations [↑](#footnote-ref-1)