Taylor University High-Altitude Research Platform as a Research Tool

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Abstract

The vision of the High-Altitude Research Platform (HARP) activity at Taylor University is to develop instruments to be flown from 1 to 40km for educational use and discovery. The new stratospheric balloon capabilities that have been developed offer new potential science capabilities including: regional or global measurements, long duration, altitude control, and *in-situ* sensing throughout the atmosphere. On going research includes global climate change, atmospheric chemistry, and enhancement of weather prediction. Instruments can measure atmospheric temperature changes of +25 to –60c and atmospheric pressure to less than 1% atmosphere. This research is so exciting because there has been very little research conducted in this environment. Students participating in HARP research have the opportunity to make many new discoveries. Several technology areas are required for this program: **Communications:** Balloons need to communicate with a ground station directly, from balloon to balloon through the mesh network, or through a communication satellite to the ground station. i***n-situ* meteorological instruments:** Temperature, Pressure, Water vapor, and Turbulence instruments will be part of all payloads. **Mobility:** The payload and ground support equipment is designed for rapid deployment and low down time between flights, High reliability and long life. **Altitude control:** Altitude control can significantly expand capabilities of a latex balloon platform by extending the flight time and maintaining a set altitude. **Data logging:** Is the logging of instrument data and GPS information onboard with a flight qualified *in-situ* Instrument package.

Communications

The primary communications to and from the Command Module, and to the ground station is with a spread spectrum 900 Mhz wireless RF module. There are two primary and one backup communications links to the balloon from the ground station with a proprietary data handling protocol which automatically varies the "over the air data rate" to maximize the transition distance. If the backup beacon module on the balloon senses that the command module has stopped communicating with the ground or with the instrument pods, it will take over the role of the command module.

The communications network can be expanded by using an IP based ground station network that links multiple stations into one database and extends the range of the tracking of balloons.
There is an Iridium module being tested to fly on the TSAT satellite on an upcoming launch provided by NASA. This module will also be incorpated into the HawkEye ballooning Network and flown on balloons to enable real time global tracking and data recovery.

In-situ Meteorological Instruments

Surface Observing Instrumentation System (SOIS)

A complete surface weather observation system is required to support the upper-air instrumentation part of the payload. To standardize and improve the quality of this observation, SOIS is being deployed as part of the ground support system. It measures the temperature, relative humidity, pressure, solar gain and winds near the location where the balloon is released or recovered.

POD Interface Module

This module is used to gather the instrument data and send it through the pod wireless network to the Command Module. The basic setup is ten analog inputs with ten bit resolution, four digital inputs, and two SMBUS ports. More details can be found in the specification section. Options include sixteen bit analogs, 2GB storage module, and a user setup program.

Airborn MET Unit

The iMet PTU module is modified to interface to the POD module. The iMet temperature sensor is a small glass bead thermistor mounted on a flexible probe. The probe and sensor are aluminum coated to maximize solar reflectivity (98%) and minimize emittance (0.02) in order to minimize temperature errors during both daytime and nighttime flights. The small size of the sensor produces very fast time response (< 3.6 seconds at sea level with 5 m/s ventilation). The sensor is factory calibrated over the full temperature range and is very stable. The humidity sensor is a variable capacitance device also mounted on the boom. It has a polymer dielectric insulator with a permittivity that varies with relative humidity. The small size of the sensor leads to fast time response. There is very little performance degradation after long-term saturation. The sensor is protected by a metalicized cap that protects the sensor while allowing adequate ventilation for accurate measurements. The pressure sensor is a compensated piezo-resistive silicon device. It is characterized by small size, fast response and excellent long-term stability.

Mobility

HawkEye system is designed for rapid deployment and flexible operation in all phases, from the flight hardware to the chase equipment. The short down time between flights is based on a proven design and high reliability.

Expanded Capabilities

Altitude Control

This technology opens up new capabilities for latex balloon envelopes in allowing for longer than two hour flights and removing the post-burst chaos for a more useful controlled descend profile. With float capability, the payload can be held at a desired altitude for a predetermined time. This allows for acquiring a large amount of data at the desired altitude and not just as the payload passes through it. This also allows the instrument to drift with the wind across a larger geographic area at an altitude where the wind speed is at low point or direction has changed. Then by adding the ballast tank it is possible to increase the altitude for profiling at different levels and ascend/descend rates.

Data Storage

Both the ground station and chase software package compiles all of the data coming from the balloons and the ground support instruments by putting a date, time stamp before storing to the MYSQL database. This management tool is used to search and merge the files for later analysis.

Astro POD Data Logger

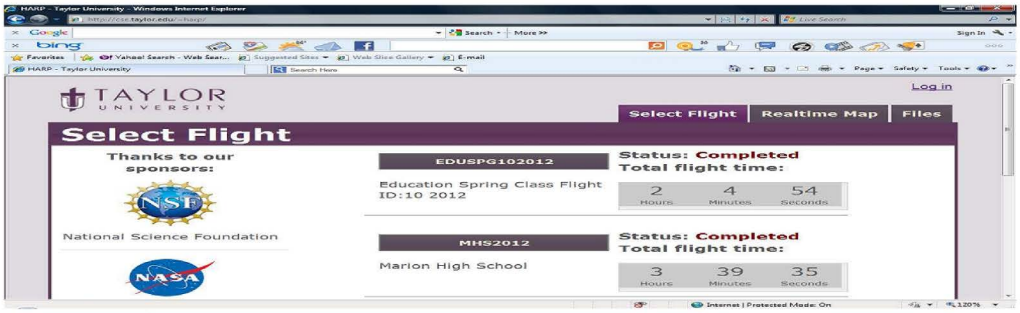
A miniature module designed for high altitude balloons, with a 2Gb SD card and flight qualified on board GPS receiver. The module has ten analog inputs, one SMBus, two digital inputs and a GPS output to interface with an APRS transmitter. Because of the small size and lightweight this unit is ideal for balloon payloads. The Optional ZigBee module can be added for wireless communication to the command module or other PODs. The module can be used as part of the HawkEye flight system or standalone logging of flight data.

Flight Termination Device

This unit is used to cut the balloon away when doing micro gravity testing of satellite deployables and as a safety device to terminate the flight in case of an emergency or to shorten a flight track.
The device is programmable for time and altitude or can be commanded from the ground station to abort.

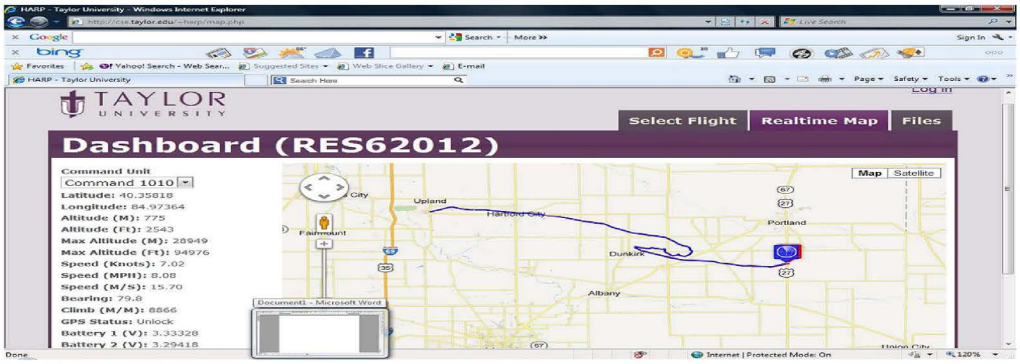
Website

This is a brand new website. It was developed as a place to hold information and resources to be used by the universities involved in High Altitude Ballooning.



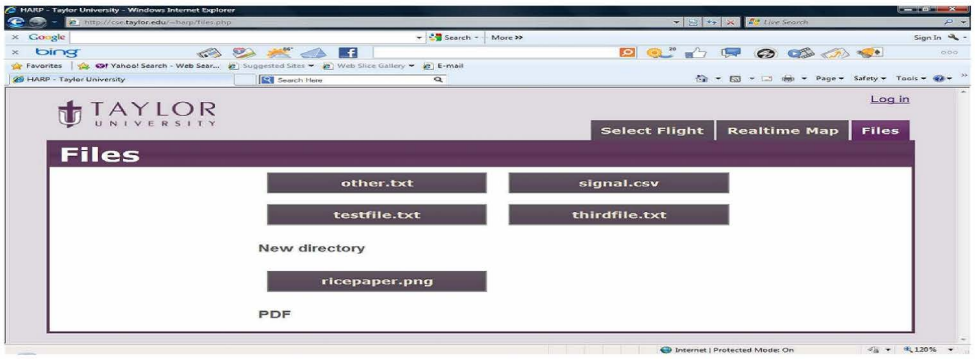
Front Panel View

From this tab you can select a flight, view the status of a flight, view the flight clock, (which will count down till launch and switch to counting up for flight duration). The status indicator will automatically change from "Preparing" to "In flight" to "Complete".



Realtime Map

This area tracks the balloon as it flies and shows only the general flight information. The exciting thing is that anyone, in the world, who is interested in the launch (such as parents or grandparents of the students) can access this webpage. However, to get detailed information about instrumentation readings the students are required to log in to the website.



File Area

There are public pages and private pages on the website. The login part of the website is information to be used only by the participants of the launch activity. They will need to use a password to get into it and can access special information about that launch that is not available to the public.

There is a directory showing the different files available to download. The users are able to find information on ballooning including: How-to Resources, Videos, Sensors, Labs, Teaching Information, Research papers, Fight Information, and more.

Hardware Specification

HawkEye Platform

Data link	
Data Packet:	5/sec
GPS Packet:	5/sec
Data Rate:	Smart Flex 9600 to 115Kbs
RF Module	
RF Frequency:	902-928Mhz
RF Type:	Frequency Hopping
Network ID:	Private
Network Type:	Mesh
RF Power:	1W
Receive Sensitivity:	-120dBm
Backup Satellite Link:	Iridium Module
Instrument Interface	
Local:	HawkEye SMBus
PODs:	ZigBee network 230Kbs
ADC Network	
Resolution:	16bit
Gain:	Programmable up to 8X
Sample rate:	1000spc
Conversion:	Continuous
Interface:	HawkEye SMBus

Adjustable Buoyancy Control

Balloon size:	200-3000gm latex
Programmable altitude:	100-65,000m
Programmable abort time:	1-48Hrs
Programmable ascent:	10-2500 fpm
Descent:	average 500 fpm
Standalone GPS:	20 Channel

GPS sampling: 5 Hz
Battery: LiPoly 8.1Vdc @ 1300mA
FAA Regulation Part 101 Compliant

Ground MET

Wind	
Speed:	0.1 – 50m/s
Direction:	0 – 360 Deg.
Temperature	
Range:	-20 to +50c
Resolution:	0.001c
Accuracy:	+/- 0.2c
Temp. sensor:	Glass bead thermistor
Humidity:	0 – 100%
Barometric pressure:	800-1100mb
ADC:	16bit resolution
Sample rate:	1000spc
Interface:	HawkEye SMBus

Three Axis Accelerometer

Range:	+- 2G
Resolution:	750mV/G
Detector:	3 Axis MEM
ADC: 16bit	
Gain:	Programmable up to 8X
Sample rate:	500spc
Conversion:	Continuous
Interface:	HawkEye SMBus

Airborn MET

Pressure	
Range:	2 to 1070 hPa
Resolution:	0.01 hPa
Accuracy:	0.5 hPa
Response time:	1 sec.
Temperature	
Range:	-95 to +50c
Resolution:	0.01c
Accuracy:	0.20c
Response time:	1.0 sec at 1000 hPa, –80 to 40c
Humidity	
Range:	0 to 100%
Resolution:	0.10%
Accuracy:	+/- 5% (-60 to +50c)
Response time:	2 sec.@ 5m/s 1000hPa +25c

POD Interface Module

Analog Inputs	
Number of inputs:	10 (programmable)
Range:	0 to +5vdc
Resolution:	10bit (optional 16bit)
Digital input	
Number of inputs:	4 (programmable)
Range:	5v TTL
SMBus	
Number of inputs:	2 (programmable)

Range:	5v TTL	
RF Module		
RF Frequency:	2.4Ghz	
Protocal:		ZigBee
RF Power:		10mW
Data Rate:		230Kbs

Flight Termination Device

Programmable altitude:	100-65,000m
Programmable abort time:	1-48Hrs
Standalone GPS:	20 Channel
GPS sampling:	5 Hz
Battery:	LiPoly 8.1Vdc @ 800mA

RF Module (For Command Control)

RF Frequency:	2.4Ghz	
Protocal:		ZigBee
RF Power:		10mW
Data Rate:		230Kbs

FAA Regulation Part 101 Compliant

2012 Research Instrumentation

Active Dipole VLF DSP Module
Electrometer / ION Detector Module

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