HASP Student Payload Application for 2012

Payload Title: **Measurement of the ozone profile in the stratosphere using improved nanocrystalline sensor arrays payload on a high altitude balloon platform**.

Payload Class: (circle one)	Institution:	Submit Date:
Small Large	University of North Dakota (UND) and University of North Florida (UNF)	12-16-2011

Project Abstract: The UND and UNF team have successfully flown payloads on both the HASP 2010 and 2011 balloon flights and measured the ozone gas profile in the stratosphere during August-September 2011. Both sensors payloads worked well during the flight and measured the variation of concentration of ozone with altitude. The nature of measured ozone profile matched very well with the theoretical expected profile. Based on the success and the few known scientific and technical problems of these payloads, the UND-UNF team proposes a HASP 2012 flight for the verification of experiment using improved version of the gas sensor arrays, hardware, software and payload. Two different groups of ozone sensor arrays: (i) nanocrystalline ITO thin film and (ii) nanocomposite ZnO-ITO and WO_3-ITO gas sensors will be used for the comparison of performance of the sensors. Instead of mounting one sensors box on one side of the rectangular shape payload, we propose to mount ozone sensor array and one light sensor on all the four sides of the payload in order to measure ozone concentration in the presence of UV light. This concept will help us understanding the effect of any shadow on the sensors, particularly at the time of sunset. In addition, a temperature sensor, a pressure sensor and a GPS will also be mounted in the payload. A hollow metal tube structure instead of metal frames will be used to make the payload body in order to reduce its mass and easy access of hardware. Ozone sensors will be fabricated and calibrated with ozone gas in low pressure chamber at UNF, and then at UND labs for the cross verification. Then, UNF sensors will be integrated with the UND electronics circuit and software to complete the payload. Both teams will jointly analyze the data after the flight. Furthermore, the surface topography of the sensors before and after the flight will be studied using a scanning electron microscope, and the chemical composition of the surface of the sensors will be analyzed by energy dispersive analysis of x-rays at UNF. This student project may be supported by both North Dakota and Florida Space Grant Consortia.

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HASP2012 Proposal

Measurement of the ozone profile in the stratosphere using improved nanocrystalline sensor arrays payload on a high altitude balloon platform**.**

Submitted by

University of North Dakota (UND)

and

University of North Florida (UNF)

Students Team:
Marissa Saad (Leader), Jonathan Snarr (consultant), Mike and others (UND),
Jason Saredy, Kenneth Emanuel, Jeremy Martin and Rebecca Polo (UNF)

Faculty Advisors:
Dr. Ronald A. Fevig (UND) and
Dr. Nirmalkumar G. Patel (UNF)

(1) Project Summary

The UND and UNF team have successfully flown payloads on both the HASP 2010 and 2011 balloon flights and measured the ozone gas profile in the stratosphere during August-September 2011. Both sensors payloads worked well during the flight and measured the concentration of ozone. The nature of measured ozone profile matched very well with the theoretical expected profile. Based on the success and few known scientific and technical problems of these payloads, the UND-UNF team proposes a HASP 2012 flight for the verification of experiment using improved versions of the gas sensor arrays and payload. Two different groups of ozone sensor arrays: (i) nanocrystalline ITO thin film and (ii) nanocomposite ZnO-ITO and WO_3-ITO gas sensors will be used for the comparison of performance of the sensors. Sensors performance will be improved by tailoring its fabrication conditions and surface modification by nanocomposite materials. The major improvement will be made on the payload body and mounting of sensor arrays. Instead of mounting the sensors box on one side of the rectangular shape payload, we propose to mount ozone sensors array and one light sensor on all the four sides of the payload in order to measure ozone concentration in the presence of UV light. This concept will help us understanding the effect of any shadow or darkness on the sensors surface, particularly at the time of sunset. In addition, a temperature sensor on the outer surface of payload to monitor the temperature of outside, a pressure sensor to monitor the atmosphere pressure and a GPS for measurement of the altitude will also be mounted in the payload. A hollow metal tube structure will be used to fabricate the payload body in order to reduce its mass and number of screws and nuts. This will allow us easy to open and close the payload for access of hardware. Ozone sensors will be fabricated and calibrated with ozone gas at low pressure in the test chamber at UNF, and then at UND for the cross verification. Then, UNF sensors will be integrated with the UND electronics circuit and software to complete the payload. Both teams will jointly analyze the data after the flight. The software will allow us to convert RAW files directly into one EXCEL file. Furthermore, the surface topography of the sensors before and after the flight will be studied using a scanning electron microscope, and the chemical composition of the surface of the sensors will be analyzed by energy dispersive analysis of x-rays at UNF. This student project may be supported by both North Dakota and Florida Space Grant Consortia.

(2) Significance of Project

ITO-QCM (Quartz Crystal Microbalance) sensor technology (Patented) and nanocrystalline gas sensor arrays technology (Patent Pending) are being developed by Dr. Patel at the University of North Florida (UNF) for the detection of toxic gases, explosive materials and chemical warfare agents with support of the Edgewood Chemical Biological Center, US Army lab, and the U.S. Department of Defense. Nanocrystalline gas sensors have also been used for the detection of ozone gas in the stratosphere. Nanocrystalline indium tin oxide (ITO) gas sensors were successfully calibrated with ozone gas at the Kennedy Space Center (KSC) and at the University of North Dakota (UND) during 2008-2009. UNF team is continuously improving the performance of ozone sensors by changing its fabrication conditions and modifying its surface structure. These sensors were successfully tested on HASP 2008 to 2011 flights. These sensors also used by the students of Louisiana State University and University of Central Florida for their weather balloon projects.

The proposed development and fabrication of different types of gas sensors and payload have several unique features. ITO gas sensor arrays have higher sensitivity and stability because of the nanocrystalline thin film structure. Earlier reported work on tungsten oxide sensors for the detection of ozone gas (Hansford *et al*., 2005) required a high operating temperature of about 450°C to detect ozone, while the UNF developed nanocrystalline ITO sensors arrays operate at ambient temperatures do not require a heater, which ultimately saves power requirements and space, and also minimizes the possibility of an accidental fire. The UNF developed nanocrystalline nanocomposite WO_3+ITO and ZnO +ITO gas sensors have high stability under harsh upper atmospheric conditions. UNF developed gas sensors arrays are very small in size, have low weight and low power consumption, which meets the payload requirements for space applications. These gas sensors can easily be integrated with microcontroller electronic circuits. Compared to the conventionally costly spectroscopic and other reference methods for the detection of ozone, our gas sensors payload is low cost and low weight for the rapid detection of gases in the stratosphere. The developed sensor payload will meet all the requirement of the HASP such as weight, size, power, communication and thermal vacuum test for the balloon flight.

(3) Work Plan

The proposed work is a continuation of UND-UNF joint efforts made during the last four years. Brief information about the output of last four HASP flights are given here as a background.

HASP 2008

The UND and UNF team made their first joint experiment to measure the ozone gas profile in the stratosphere through the HASP 2008 flight. The payload was launched on a HASP balloon flight and remained airborne for about 32 hours. The payload and data were recovered. The UND-UNF sensors and payload successfully measured the profile of ozone at different altitudes. The measured ozone profile nearly matched with the expected theoretical profile, but the maximum magnitude of the measured value of ozone was smaller by a few ppm than that of the expected value because of the effects of hurricane Ike during the flight period. Pictures of payload during the HASP 2008 flight and measured ozone profile are shown in fig. 1. One thesis for a master’s degree and one research paper presented and published at an international conference (Ambler *et al* 2008) were major outputs of the HASP 2008 project.

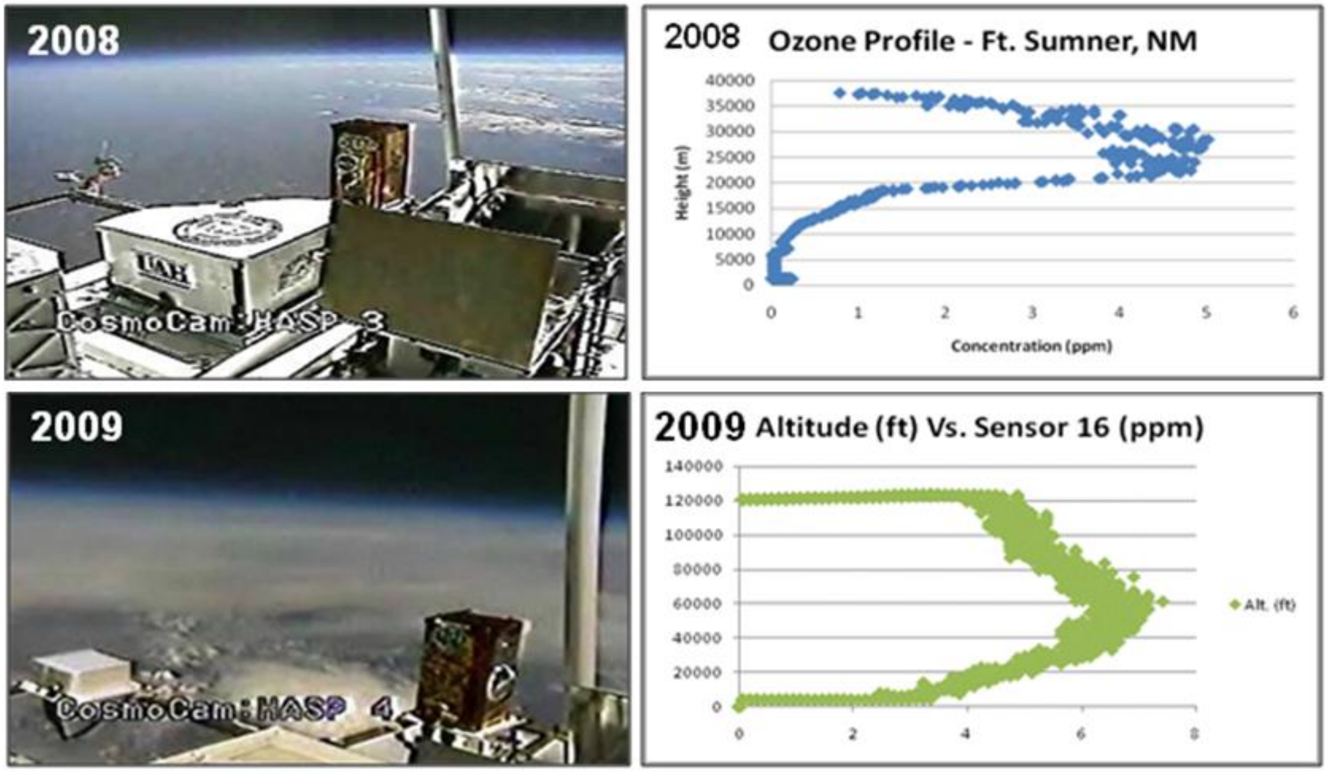

Fig. 1 UND-UNF payload on HASP 2008 and 2009 balloon flights and measured ozone profiles

HASP 2009

Based on this fruitful experimental work from HASP 2008, the UND-UNF team participated in the HASP2009 flight using three different groups of sensor arrays with the support of FSGC. During the first thermal vacuum test, a few electronic components failed and were replaced. One voltage regulator for one of the three sensor array groups failed after the second thermal vacuum test and was not replaced. The payload was certified to fly with two groups of sensor arrays. All 15 sensors measured the ozone profile during the balloon flight during the ascent. The measured ozone profile at different altitudes matched the expected theoretical profile (fig.1). One thesis for an honor's degree and one research paper were prepared based on the HASP2009 project.

HASP2010 and 2011

Both 2010 and 2011 flights were made during August-September 2011. HASP 2010 payload cleared two times the thermal vacuum tests without any problem. Nanocomposite of ITO with ZnO, WO_3 and TiO_2 were used for the fabrication of sensors. The major improvement was made in the performance of sensors, sensors packaging, electronic circuit and software to convert RAW files into one EXCEL file. New software developed by Jonathan reduced time for the data analysis. GPS and pressure sensors were added in the 2011 payload. Most of sensors worked well and measured the ozone profile. Fig. 2 shows the pictures of both payloads during the flights and measured ozone profiles. The nature of measured ozone profile was matched well with the theoretical profile. We are expecting to make one research paper.

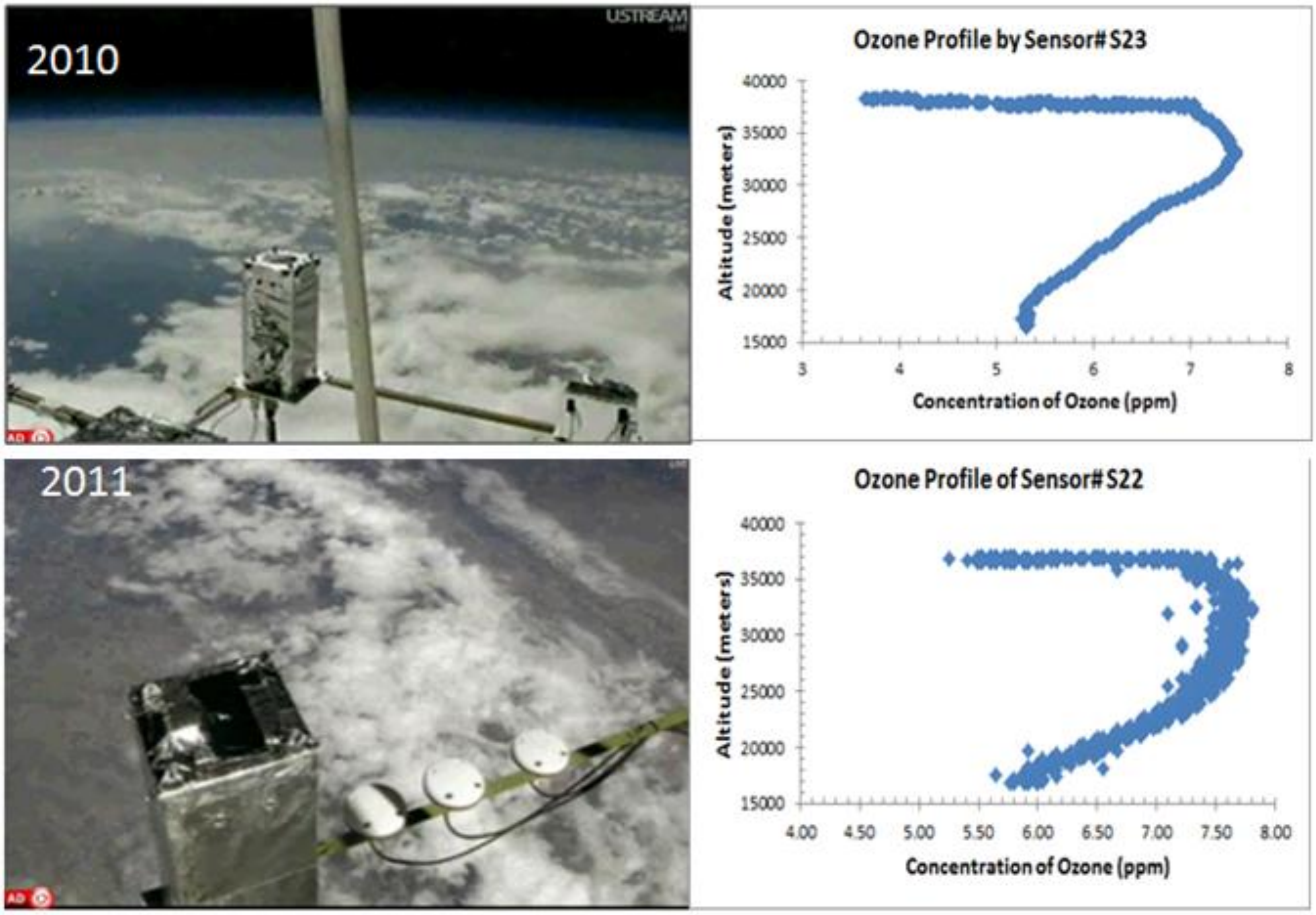

Fig. 2 UND-UNF payload on HASP 2010 and 2011 balloon flights and measured ozone profiles

Work Plan for the Proposed Science Experiment

Based on the success and few known scientific and technical problems with the HASP 2010 and 2011 balloon flights made during 2011, the UND-UNF team proposes a HASP 2012 flight for the measurement of ozone profile in the stratosphere using improved version of the gas sensor arrays and payload.

(i) Two different groups of ozone sensor arrays: (i) nanocrystalline ITO thin film and (ii) nanocomposite ZnO-ITO and WO_3-ITO gas sensors will be used for the comparison of performance of the sensors. Sensors performance will be improved by tailoring its fabrication conditions. All sensors will be calibrated simultaneously in the low pressure chamber in order to minimize the experimental error for the trendline equations of the plots for converting resistance values into concentration of ozone. The pressure and temperature inside the test chamber will be kept as those in the stratosphere. Ozone sensors will be again tested at UND for the cross verification.

(ii) The major improvement will be made on the payload body and mounting of sensor arrays. Instead of mounting the one sensors box having 24 gas sensors on one side of the rectangular shape payload, we propose to mount 6 gas sensors and one light sensor on each of the payload body. In the presence of UV light, sensors mounted on all the four sides of the payload will measure ozone concentration. Amount of UV light will be detected by the light sensor, while its interaction with oxygen to convert into ozone will be detected by ozone sensors. This concept will help us understanding the effect of any shadow or darkness on the sensors surface, particularly at the time of sunset. The HASP balloon platform may oscillate or rotate in the different directions during the flight. There may be possibility that sensors may go opposite direction of sun and get less UV light.

(iii) In addition, (i) one temperature sensor will be mounted on the outer surface of payload to monitor the temperature of outside of the payload, (ii) one pressure sensor will be added to monitor the atmosphere pressure and (iii) the GPS will also be added for measurement of the altitude.

(iv) Instead of using several aluminum L-channels and plastic sheets, a single hollow metal tube structure will be used to make the payload body. This will reduce the numbers of screws and nuts and hence weight of the payload. This will also allow us to open and close the payload easily for access of the hardware.

(v) Thermal blanket for the payload will be improved and its performance will be checked at UNF.

(vi) UNF sensors will be integrated with the UND electronics circuit and software to complete the payload.

(vii) Both teams will jointly analyze the data after the flight. The software will allow us to convert all RAW files directly into one EXCEL file. Then, applying trendline equations to convert resistance values into concentration of ozone gas.

(viii) The surface topography of the sensors before and after the flight will be studied using a scanning electron microscope, and the chemical composition of the surface of the sensors will be analyzed by energy dispersive analysis of x-rays at UNF.

(ix) The developed payload may work for rapid detection of ozone in the real time mode and may be useful for the space and environmental applications.

Working Principle of Gas Sensors

Interaction of ozone gas on surface of n-type ITO thin film gas sensor

Upon adsorption of charge accepting molecules at the vacancy sites from oxidizing ozone (O_3) gas, electrons are effectively depleted from the conduction band of ITO. Vacancies can be filled by reacting with ozone. Filled vacancies are effectively electron traps and as a consequence, the resistance of the sensor increases upon reacting with ozone.

Oxygen vacancy (V) + Ozone (O_3) $\rightarrow$ Lattice Oxygen site (O_o) + O_2

Fabrication of Gas Sensor Arrays

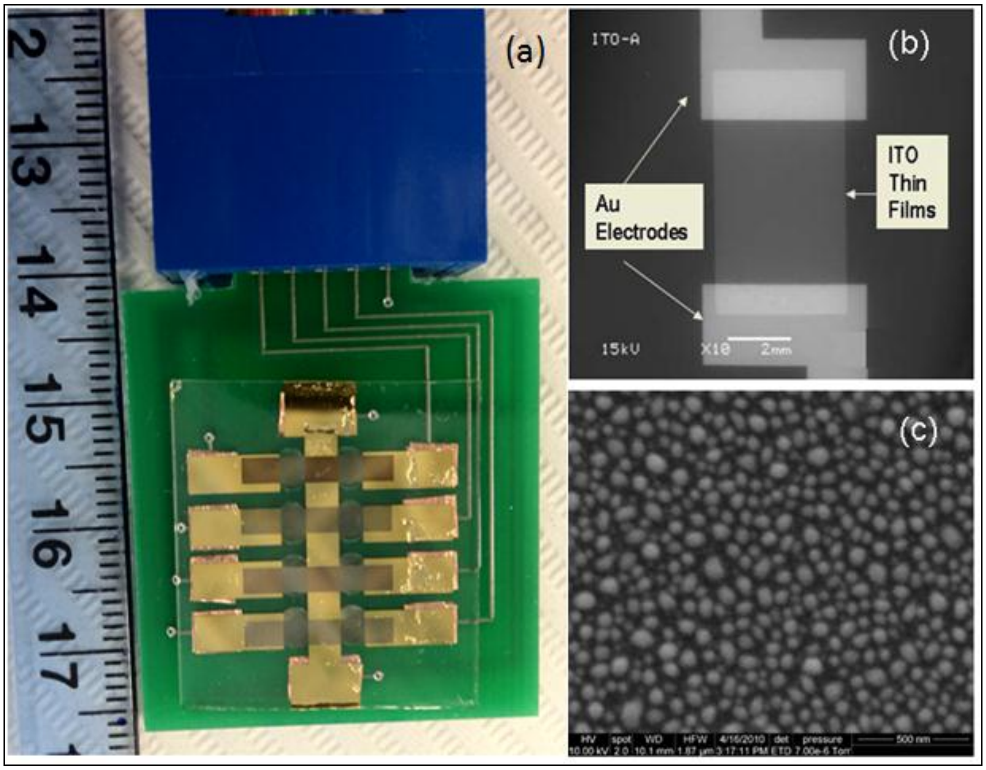

Fig.3 (a) 8 sensor array and interface mini PCB, scanning electron micrograph of (b) top view of one ITO gas sensor and (c) nanocrystalline grains of ITO thin film

Nanocrystalline ITO thin film gas sensors array (UNF patent pending) will be fabricated over the cleaned glass substrates. Fig. 3(a) shows the top view of 8 sensor arrays and the interface printed circuit board. Fig. 3(b) shows a scanning electron micrograph of one ITO thin film gas sensor having two gold electrodes for external electrical contacts. Fig.3(c) shows a scanning electron micrograph of nanocrystalline gains of the ITO thin film. Two different groups of gas sensor arrays will be fabricated at UNF. Each group will consist of 4 nearly identical sensors. Both groups of sensor arrays will be fabricated on a 1 inch x 3inch ultra cleaned glass substrate and mounted on to the interface circuit board as shown in Fig.3. Group-1 will consist of four nanocrystalline ITO thin film gas sensors array fabricated on a glass substrate. Group-2 will consist of a two nanocomposite ZnO+ITO and two nanocomposite WO_3+ITO thin film gas sensors array fabricated on the glass substrates. Each group of sensor arrays will have different sensor characteristic parameters for the detection of ozone gas.

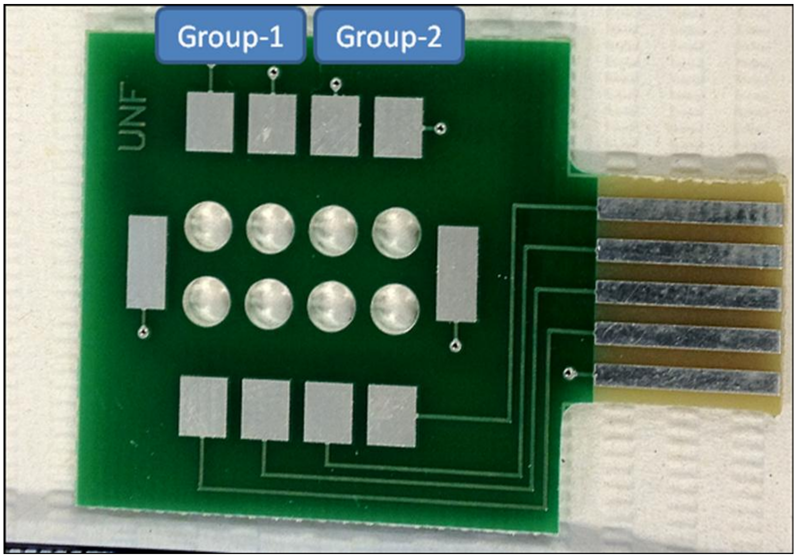

Fig. 4 Schematic diagram of 2 groups of sensor arrays mounted on mini PCB

The sensor array will be interfaced with the printed circuit board and its 10-pin connector and cable. Sensors will be tested and calibrated with ozone under low pressure at UNF. An ozone generator (Ozone Solutions, Model# OMZ-3400) will be used as the source of ozone, which generates 0 to 12 ppm ozone gas. A digital ozone detector (Eco Sensors, Inc., Model:A-21ZX) will be used to measure the concentration of ozone. Keithley electrometer and multimeter with LabView software will be used to measure ressirance of all sensors simulataneously in the test chamber. The parameters of trendline equations of calibration plots will be used for the determination of concentration of ozone. The surface morphology of the gas sensors and CSTFTs before and after recovery of the payload will be examined using a scanning electron microscope (SEM) at UNF. The chemical composition of the sensors will be determined using Energy Dispersive Analysis of X-rays (EDAX) at UNF in order to check for any possible damage and contamination on the surface of the sensors occurred during the flight.

Fabrication of payload

A miniature, flexible, and low power heater (Omega Inc.) will be integrated on to the backside of the sensor arrays. The purpose of the heater is to combat the low temperatures of the troposphere and keep the sensors at a nearly constant temperature in the range of 25 to 30°C. A miniature temperature sensor will also be mounted to monitor and control the temperature of the sensors using a closed loop control electronics circuit. The sensors array with a printed circuit board will be mounted in a low weight aluminum box. Four boxes will be mounted on the four sides of the low weight payload body. Outer temperature sensor and GPS antenna will be mounted on the top plate of the payload. The wall of the payload will be covered by a thermal blanket. A miniature low power fan will be mounted on the front of the sensor box to push gas molecules over the surface of the sensors. The fan will mainly work during the upward and downward journey of the flight. The fan may stop rotating during float in the stratosphere because of the low pressure. A wire mesh will be fixed over the fan in order to filter out dust particles and protect the surface of the sensors. The sensor box containing the sensors, fan, heater, and temperature sensor will be interfaced with the microcontroller circuit and payload.

UND and UNF Team Structure

The team structures, distribution of work and management methods will remain largely the same as last year with inclusion few new students. Fig.5 shows the chart for the team management

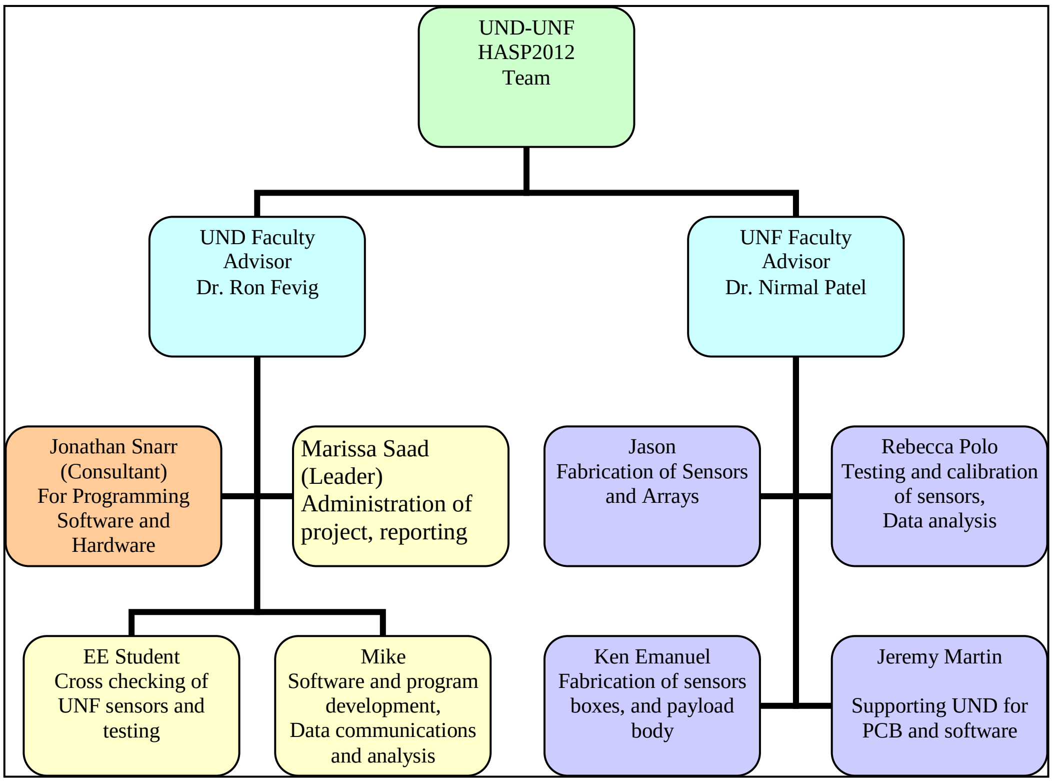

Fig.5 Team Management

UND-

(1) Marissa Saad (Student Leader) is an astronomy graduate research student. She will take care of the organization of meeting and teleconference meeting with all members and faculty advisors, and communicating with the HASP. She will take lead for the integration and thermal vacuum testing of payload at Palestine, TX and pre-flight testing at Fort Sumner, NM. She will also responsible for the flight operation plan, monthly reports, and updating of progress of work and any issue to both the advisors.

(2) Jonathan Snarr (Consultant) was a student leader of HASP2010 and 2011 flights. He developed of the new version microcontroller circuits, GPS and software for the payload. He will continue to help the UND-UNF team for electronic circuits, hardware and software work and also provide all previous version of software and hardware to the team. He will responsible for assisting all the members of the team.

(3) Mike is undergraduate electrical engineering student. He will develop the electronic circuit board, software, interfacing of sensors and integration of payload with HASP platform.

(4) One EE student will help with the software work as well as the HASP communication line with payload.

(5) Additional, yet unidentified members will be added to the effort as the needs arise.

UNF –

(1) Jason Saredy is a graduate Physics- Biology student and was an active participant in the last four HASP efforts. He will useful for the fabrication of the gas sensor arrays

(2) Rebecca Polo is an undergraduate chemistry student and was an active participant in the data analysis of HASP2011. She will be responsible for testing and calibration of sensors. She will also perform the post flight data analysis work and report work.

(3) Ken Emanuel is an undergraduate mechanical engineering student and was an active participant for HASP2011 efforts. He will design and fabricate sensor array boxes and payload body and integrating sensors with flexible heater, temperature sensor and fan in the metal box. He will also integrate the payload body and mount the sensors box in the payload.

(4) Jeremy Martin is an undergraduate electrical engineering. He will work with UND team for PCB, hardware and software work and also support to Ken.

Task and Work Plan Path

The initial work break down schedule (WBS) includes the basic tasks required of the HASP project, which includes the Proposal, Integration Plan, Integration Certification, Operation Plan, and Science Report. However, this schedule also includes the strong intent to fly an identical payload locally through the High Altitude Ballooning group at the University of North Dakota (UND), this task includes creating an identical bus to that of HASP so that all anomalies can be detected in a true flight mode. Work plan path is given in Fig.6.

2012	UND	UNF
January	Conceptual Design Review (CoDR) for sensors, electronic circuits, software and payload. Reviewing issues of HASP2008 to 2011 flights.	
February	Preliminary Design Review (PDR) for sensors, electronic circuits, software, payload, integration of payload with HASP and data analysis.	
March	Critical Design Review (CDR) for sensors, electronic circuits, software, payload, integration of payload with HASP and data analysis.	
April	Designing of circuit board and programming.	Fabrication and testing of sensor arrays, designing of payload body
May	Fabrication of circuit board and programming	Calibration of sensors and delivery of sensor arrays to UND for testing
June	Testing of circuit and sensor arrays. Integrating the circuits and the sensor arrays	Fabrication of sensors box and payload body. Reviewing HAP2010 flight, data and any issues.
July	Integration of circuit board and sensor box with the payload body. Development of protocols for	Integration of sensor arrays in box. Integration of sensor boxes with payload body. Integration of PCB to payload and sensors box

	communication of payload with HASP computer and RAW files to EXCEL file	
August	Flight operation plan, Testing payload, thermal vacuum test of payload and integration of payload with HASP platform	
September	Pre-flight testing of payload, launching of payload and downloading data files, and data analysis work	
October	Payload recovery, testing of sensor arrays and other components, SEM+EDAX analysis of sensor arrays and shorting of issues and failure analysis. Data analysis.	
November	Data analysis and report writing	
December	Submission of the science report and then enjoying holidays.	

Fig. 6 Work plan path

HASP Integration

It is expected that a minimum of three students from UND and UNF and one faculty member from UND/UNF will travel to CSBF, Palestine, Texas in first week of August of 2012 (as per the date given by HASP) for the integration of the sensor payload onto HASP. It is also expected that approximately four students from UND and UNF and two faculty members (UND and UNF) will travel to Ft. Sumner for launch of the HASP2012 payload during September 2012 (as per the date given by HASP and CSBF).

Payload Specification

The sensors' operations and ozone gas measurements are processed according to the improved version of electronic circuits given in Fig. 7 to 9. The actual circuit will be based on modified version of Figs. 8 and 9. Resistance values from the ozone gas sensors and pressure sensor are converted to voltages by the conditioning circuitry. The drain current of chemical sensitive thin film transistors will be converted in to appropriate conditioning circuitry. These analog values are converted to digital values by a microcontroller which interfaces with the HASP data handling system. Temperature sensor and pressure sensor readings are processed in a similar manner and are folded into the data stream by the microcontroller. Power from HASP is conditioned by circuitry based on voltage regulators and is provided to each payload electrical subsystem.

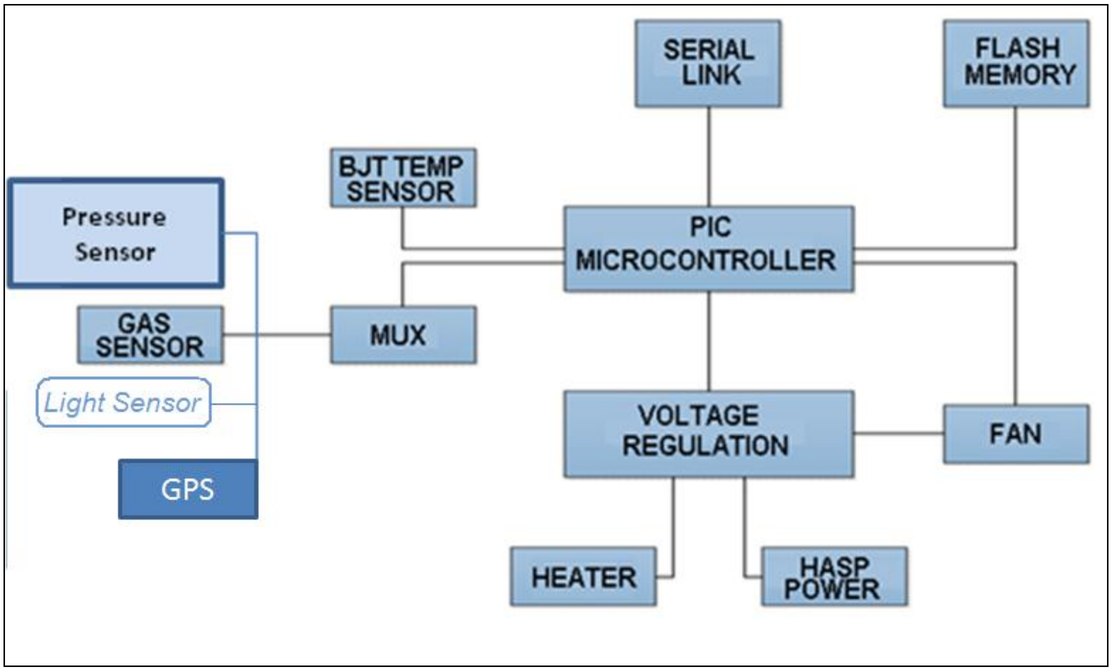

Fig.7 Block diagram of electronic circuit

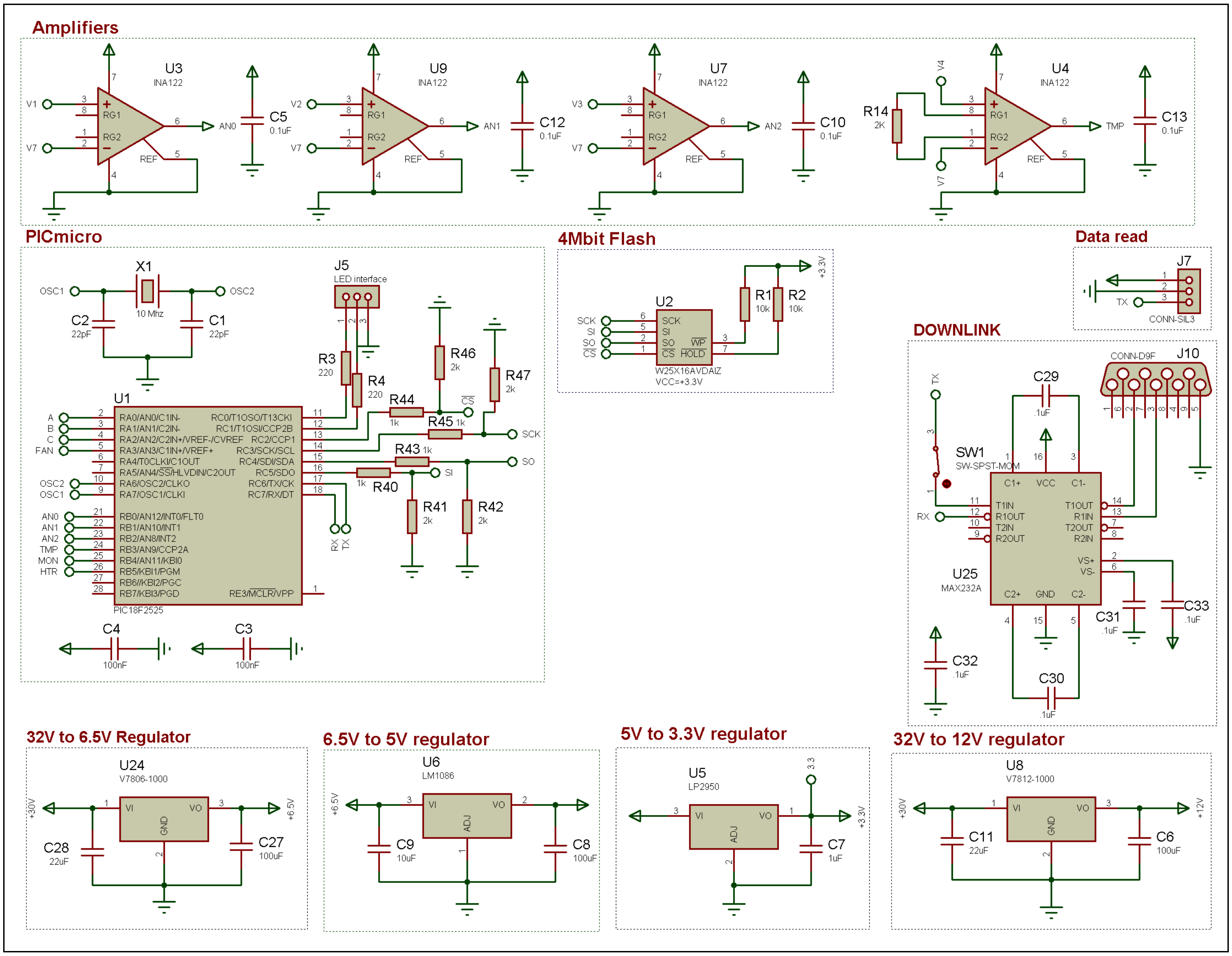

Fig.8 Electronic circuit for amplifier, microcontroller, voltage regulator and downlink

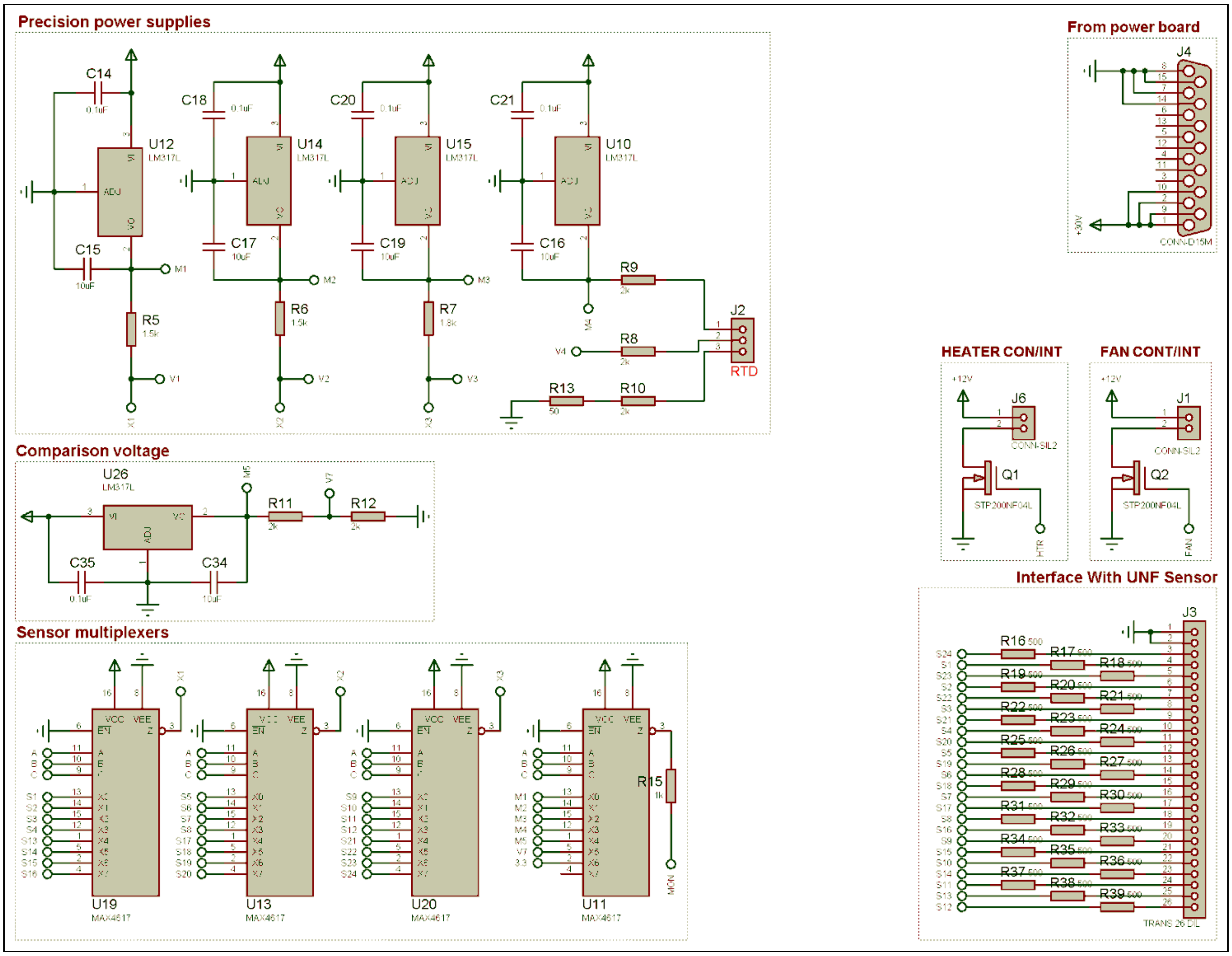

Fig.9 Electronic circuits for multiplexer and power supply

Mounting Footprint

Selection of the small payload dictates the mounting plate that interfaces with the payload. This mounting plate design is provided in the HASP Student Payload Interface Manual (Version 02.17.09) and is shown below in Fig.10. This mounting plate design will not require modification.

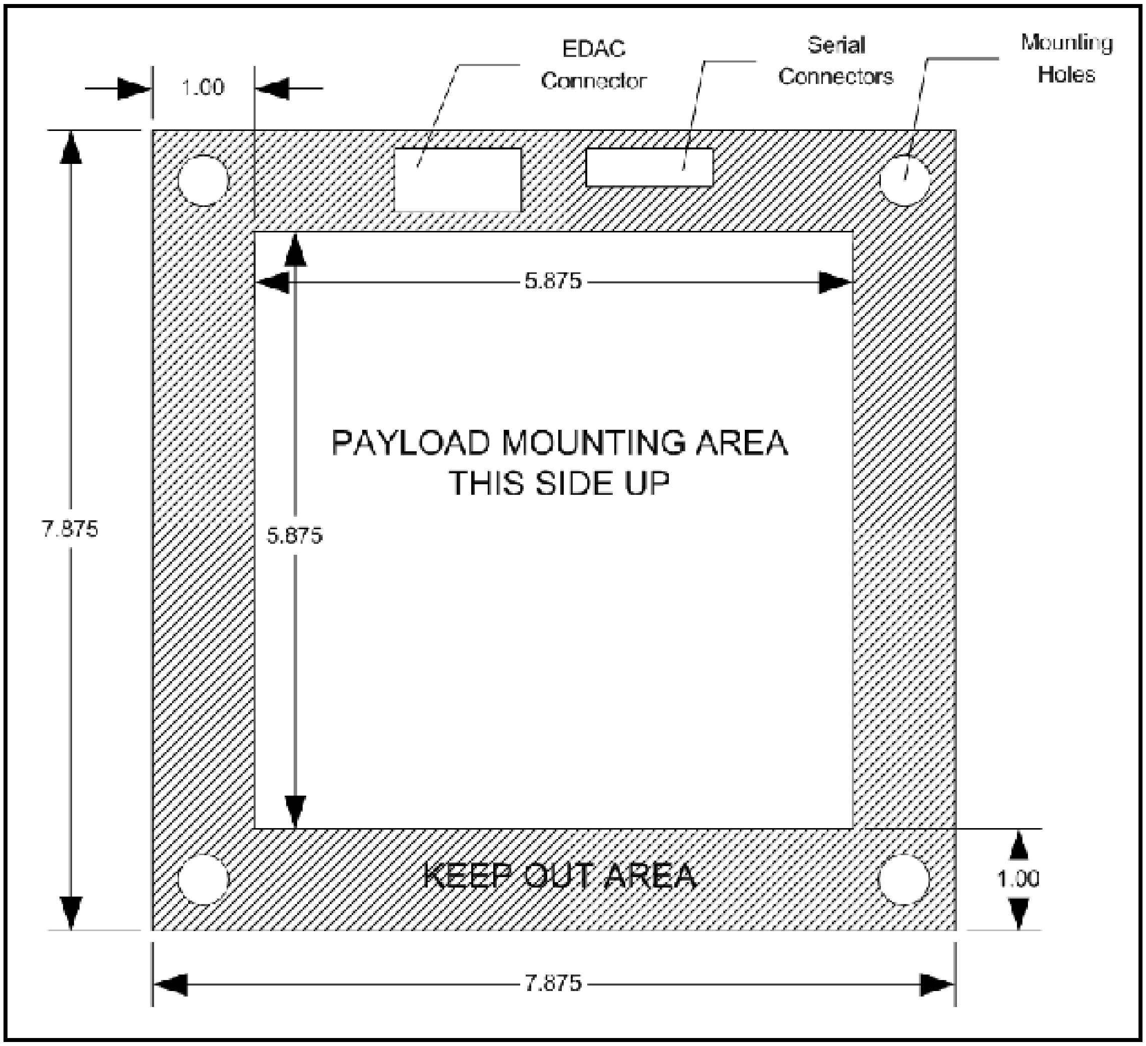

Fig. 10 Mounting Plate for small payload (Courtesy: HASP Version 02.17.09)
http://laspace.lsu.edu/hasp/documents/public/HASP_Interface_Manual_v21709.pdf

Desired location and orientation

The requested smaller payload should be oriented on the side away from any solar cells to avoid disparate solar thermal radiation. There should not be any obstacle for air circulation into payload and also any shadow of other payload. We also prefer that CosmoCam camera should be able to view our payload, particularly at the night time to watch the blinking of LED for the data collection. We would like the position of the payload (#7) on HASP to be the same as in the previous 208 to 2010 flights. Fig. 11 shows our desired location of payload on HASP.

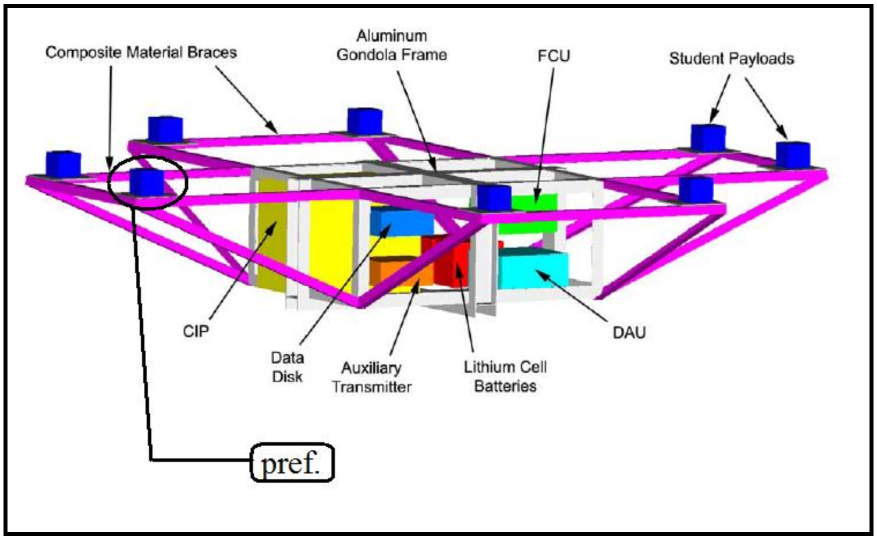

Fig. 11 Proposed HASP Configuration (Guzik and Wefel, 2004)

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Payload Dimension

The proposed payload is under the category of small payload. The height of payload will be within 30 cm and sides will be within 15 cm x 15 cm. Payload mass will be within 3.00 kg. Mass of our HASP 2008 to 2011 payloads was about 2.00 kg. We want to further reduce the weight this time.

Payload Mass Budget

The weight budget is itemized below in Table 1.

Table 1 – Itemized Mass Budget

Item:	**Mass:**
Sensor arrays boxes (including fan, heater, box)	200g
Electronic circuits board	250g
Payload body and top plate	550g
Payload sides, nuts and screws and thermal blanket	200g
Cables and any other items	100g
Total	**1300g**

The expected mass of payload will be about 1.30 kg without HASP mounting plate, which is quite less than the 3.0 kg limit for the smaller payloads.

Payload Power Budget

The 0.5 Amps at 30 VDC power supplied by HASP adequately accommodates the power requirements for the payload electronics, as well as the heater and fan for the sensor. Table 2 details the preliminary estimate for our power budget

Table 2 – Itemized Power Budget

Item:	**Power requirement:**
Payload Electronics	1 W
Sensor Heater	7 W (max.)
Sensor Fan	2 W
Total	**10 W**

This is less than the 15 W limits for the smaller payloads.

Preliminary heat transfer calculations, utilizing such equations as shown in equation 1, heat transfer, showed the onboard sensor heater is adequate to keep the sensor at nominal conditions. An additional exploration of the effects of temperature on component integrity is ongoing, and part of the investigation. These initial estimations utilized the proposed materials for the walls, and a minimum temperature of -60°C and a general operating temperature of 15°C (found from altitude variation from 0 km to 36 km shown in the modified Fig. 12, altitude profile).

Equation 1 – Heat Transfer

$$q = m(\Delta T)C_p$$

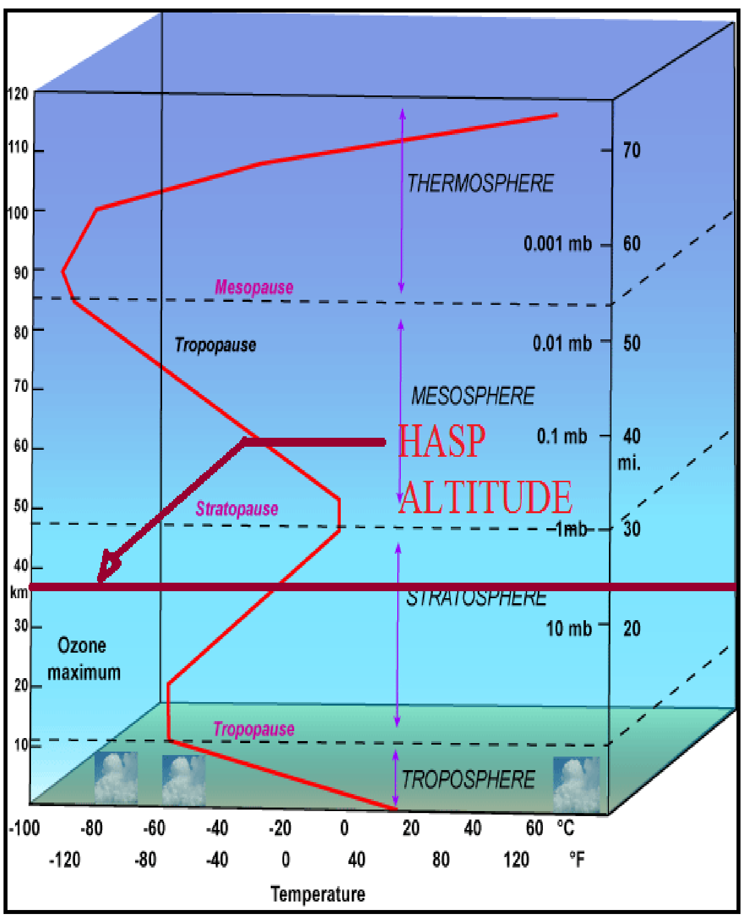
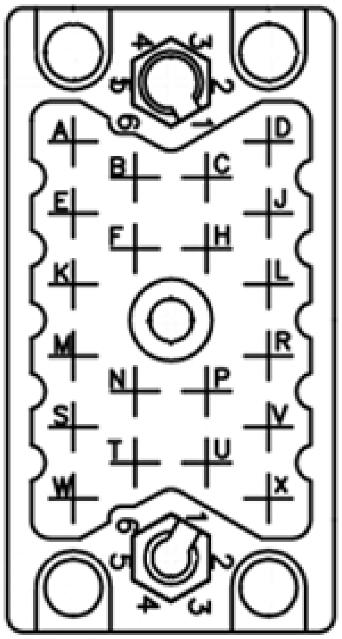


Fig. 12 – Modified Altitude Profile (Atkins, 2007)

As per the instructions, on the EDAC 516 power connector only pins A,B,C,D are wired to the payload as +30 VDC power supply and pins W,T,U,X are wired to payload as power ground to avoid failure to the power circuit or loss of payload. A voltage regulator is not necessary according to initial tests despite the slightly higher +33 VDC at launch for the sensor; however, a voltage regulator and divider will be used for peripherals. Fig. 13 shows the EDAC516 receptacle pin layout.



Function	EDAC Pins	Wire Color
+30 VDC	A,B,C,D	White with red stripe
Power Ground	W,T,U,X	White with black stripe
Analog 1	K	Blue
Analog 2	M	Red
Signal Return	L, R	Black
Discrete 1	F	Brown
Discrete 2	N	Green
Discrete 3	H	Red with white stripe
Discrete 4	P	Black with white stripe

Fig. 13 EDAC516 receptacle pin layout (Courtesy: HASP manual).

Downlink Serial Telemetry Rate

The payload module requires the RS232 HASP telemetry to send the state of resistance to the ground. A data-recording unit will be included with master controller in the event that the telemetry link fails. The DB9 connecter is required to the HASP system’s telemetry system so that the data can be sent to the base station via the RS232 link. The RS232 link will operate at 2400 baud, with the standard RS232 protocol with eight data bits, no parity, one stop bit, and no flow control. A standard packet will contain the information-formatted vis-à-vis the Student Payload Serial Connection section of the HASP-Student Interface Document. Fig. 14 shows DB9 pin diagram.

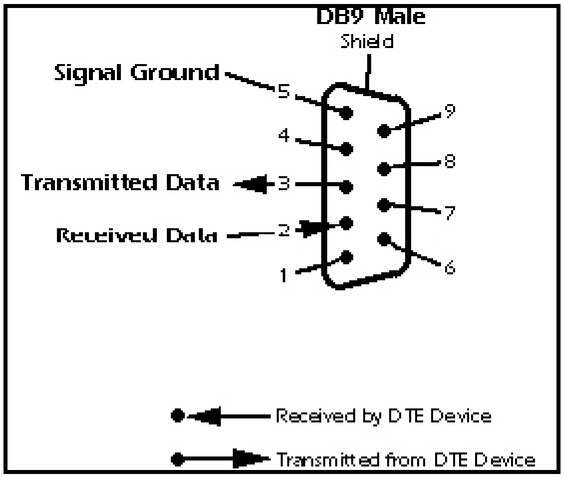


Fig. 14 DB9 pin diagram (courtesy: HASP manual)

Uplink Serial Command Rate

No uplink commands are anticipated.

Anticipated Use of analog downlinks

No additional analog downlinks are anticipated.

Payload

There will be no hazardous chemicals, gases and biological samples or parts in the payload.

Anticipated Additional Discrete Commands

No additional active discrete commands are anticipated.

Anticipated Procedures

Prior to Integration:

- Testing and Calibration of sensor arrays
- Set initial values for data recorder
- Place sensor arrays in appropriate payload slots
- Check program and LED for status

Integration:

- Mount payload module to HASP
- Connect HASP Power Connector
- Connect HASP Serial Connection
- Test system by recording initial readings and making sure all data is nominal
- Troubleshoot

Pre-Flight Operations and testing:

- Set initial values for data recorder
- Place sensors in appropriate payload slots
- Check all batteries

- Connect HASP Power Connector
- Connect HASP Serial Connection
- Check mass and size pf payload
- Test thermal-low temperature and high temperature test
- Test pressure and vacuum test
- Test 10g vertical and 3g horizontal vibration/impact test

Flight Operations:
- Record values for resistance across the sensors

Post-Flight Operations:
- Examine all parts of payload
- Remove PCB and sensors box from the payload. Test PCB with power and test sensor box
- Send sensors box to UNF for electrical testing, SEM+EDAX analysis, and failure analysis.

Financial Considerations

UND will seek funding through North Dakota Space Grant Consortium. UNF will request Florida Space Grant Consortium for the funding for the students support, travel and consumables.

References

(1) Solid-State Sensors Behavior in Reduced Pressure Environments Demonstration Using an Experimental Indium Tim Oxide Ozone Gas Sensors for Ozone Sounding Nathan Ambler, Ronald Fevig and Nirmal Patel, Proceedings of 59th International Astronautical Congress , Glasgow, (Sept 29-Oct 3, 2008), C2.I.17

(2) Hansford, Graeme M., et al. "A low cost instrument based on a solid state sensor for balloon-borne atmospheric O3 profile sounding." Journal Environmental Monitoring (2005): 158-162.

(3) Guzik, T. Gregory and John P. Wefel. "The High Altitude Student Platform (HASP) for Student-Built Payloads." 35th COSPAR Scientific Assembly. Houston, Texas, 2004. 1-8.

(4) HASP – Student Payload Interface Manual, Version 02.17.0 http://laspace.lsu.edu/hasp/documents/public/HASP_Interface_Manual_v21709.pdf

(5) Atkins, Noel. Survey of Meterology. 10 November 2007 http://apollo.lsc.vsc.edu/classes/met130/notes/chapter1/vert_temp_all.html