February 24, 2012

To: Dr. T. Gregory Guzik - HASP Project Director
From Patrick Doyle - U of MN High Altitude X-Ray Detector Testbed (HAXDT) Team Lead
RE: HASP 2012 Student Payload Summary Response

This document addresses the weaknesses found in the University of Minnesota's (UMN) 2012 HASP proposal. The weaknesses addressed in the payload summary were related to the following aspects of UMN's High Altitude X-Ray Detector Testbed (HAXDT): student participation; thermal protection and testing at integration; uplink and downlink utilization; and power connectivity and voltage conversion. There were also weaknesses identified in the abstract. As such, a revised abstract is given below followed by our responses to the respective weaknesses listed above.

Abstract

The work described in this proposal is motivated by the idea of using celestial x-ray sources such as pulsars as beacons for deep space navigation. The development of a compact x-ray detector system is crucial to this concept. Such a system placed on envisioned future deep space vehicles could be used to generate an accurate navigation solution at low power levels while taking up little space. The engineering objective of the proposed experiment is to test and validate the performance of a compact x-ray detector and its associated flight computer. The main science objective of the experiment is to characterize the background x-ray noise at the HASP flight altitudes. The educational objective is to give students a hands-on experience in designing and testing of avionics systems. To this end, a student-led team will perform all construction and testing of the University of Minnesota's High Altitude X-Ray Detector Testbed (HAXDT) with the support of two faculty advisors and two industry collaborators. HAXDT will be designed to conform to a 2-u CubeSat infrastructure with a 2000 cm^3 internal payload volume. There will be minor modifications to the payload mounting plate in order to secure HAXDT to the plate. Current interface requirements include less than 15 watts of power, less than 1200 baud of downlink bandwidth, and the ability to reset the system via uplink commands.

Student Participation

HAXDT will be constructed by a student team led by Patrick Doyle as part of his Masters of Science thesis work on x-ray navigation. Mr. Doyle will also serve as systems engineer, while focusing on integration of the x-ray detector and GPS receiver. One graduate student will lead the design of the power management system and will also be responsible for flight computer operations (i.e. data logging and signal processing). One undergraduate student has been recruited to assist in integration of the attitude determination system. Additional undergraduate participants have been recruited through the Minnesota Space Grant Consortium High-Altitude (Weather-) Ballooning Team to design and construct the structure and the thermal protection system. Current student participants and their responsibilities are listed in Table 1 below.

Name	Academic Level	Responsibilities
Patrick Doyle	Graduate Student – 1st year	Team Lead and systems engineer. X-Ray detector and GPS integration
Curtis Albrecht	Graduate Student – 1st year	Power management design and flight computer operations.
Steven Haviland	Undergraduate – Senior	Attitude determination sensor integration.
Sean Grogan	Undergraduate – Soph.	Structure design and mechanical drawings.
Zach Fadness	Undergraduate – Fresh.	Structure design and construction.
Ryan Carlson	Undergraduate – Soph.	Thermal protection and monitoring.
Brian Erickson	Undergraduate – Soph.	Thermal protection and monitoring.

Table 1. Current Student team, academic level, and responsibilities

Thermal Protection and Testing

The maximum allowable operational temperature range based on the current hardware configuration is -40 to +85°C. The flight computer, GPS receiver, IMU, and detector hardware will be insulated from the ambient environment. Based on data from previous HASP flights (acquired from the Inter-American University of Puerto Rico team), the ambient environment is expected to surpass -60°C for a few minutes during the ascent and a second time during the descent. The detector will be exposed to the atmosphere and although the detector's thermal properties are unknown at this time it is assumed that it will function properly when exposed. This is justified because we are acquiring a detector that is being designed to fly in outer space. Temperature will be monitored in the insulated area of HAXDT and if it approaches the minimum operating temperature, electrical resistive heaters will be activated to raise the temperature to an appropriate level.

Since it is likely that payload systems will overheat without treatment, HAXDT will be tested in a thermal vacuum chamber at the University of Minnesota to simulate HASP flight conditions. The temperature of all components will be monitored in order to determine if and when the components will reach their maximum temperature. If it is found that the maximum temperature is reached in the simulated environment, then appropriate measures will be taken in order to dissipate heat. One planned measure is to coat the exterior surface of HAXDT with a reflective material (i.e. silver or white paint) to reduce radiation effects from the Sun. This measure will be implemented when materials are chosen and construction of the structure begins. Another measure may include the addition of heat sinks that will pass heat to the HAXDT structure, thus increasing the surface area available for heat transfer.

The use of a thermal vacuum chamber at the University of Minnesota will allow iterative testing of such thermal control measures. These measures will therefore be improved upon if necessary, until an appropriate overheating solution is found. Thermal vacuum testing done prior to integration will also help ensure that HAXDT will pass any testing performed at integration in July.

Uplink and Downlink Utilization

The downlink will be used to send a packet of information once every minute including temperature, GPS position and velocity, angular rates, and total number of x-ray detector and IMU data packets recorded. If the received data indicates that data logging has been suspended or interrupted (i.e. number of detector packets or GPS position remains unchanged between updates), then the uplink will be used to send a command to reset data collection. Data will be sent and received by HAXDT using the RS-232 serial connection to the HASP flight system using a DB9 female connector.

Power Connectivity and Voltage Conversion

A schematic of power system connections is shown in Figure 1 below. Power will be provided to HAXDT via the EDAC 516 interface with the HASP flight system. Pins A, B, C, and D from the EDAC 516 interface will be soldered together and passed through a power supply buffer to be designed for protection to both the HASP flight system and HAXDT during operation. Power will then be passed through a PT6886A or similar DC/DC regulator. The regulator will convert the 30 VDC nominal voltage provided by the HASP flight system to 12 VDC. The regulator is capable of providing a 12 VDC output for an input range of 18 to 36 VDC, thus any deviation from nominal power will provide a constant 12 VDC to HAXDT systems.

The 12 VDC will be supplied to the HAXDT daughterboard shown in Figure 2, which has built in regulators that supply power to all components through 3.3 VDC and 5 VDC lines. The daughterboard has been developed by the Aerospace Engineering and Mechanics UAV Research Group at the University of Minnesota – Twin Cities [1] and has flight heritage on UAV's. The daughterboard will be used to mount the flight computer and connect all components via a wiring harness as shown in Figure 3 below.

A separate 30 VDC line is shown in Figure 1 before the DC/DC regulator. This line is placed to allow for unforeseen power requirements that may arise. Such requirements may involve the thermal protection system and the x-ray detector. However, it is currently expected that the detector will be powered by the 5 VDC line provided by the daughterboard.

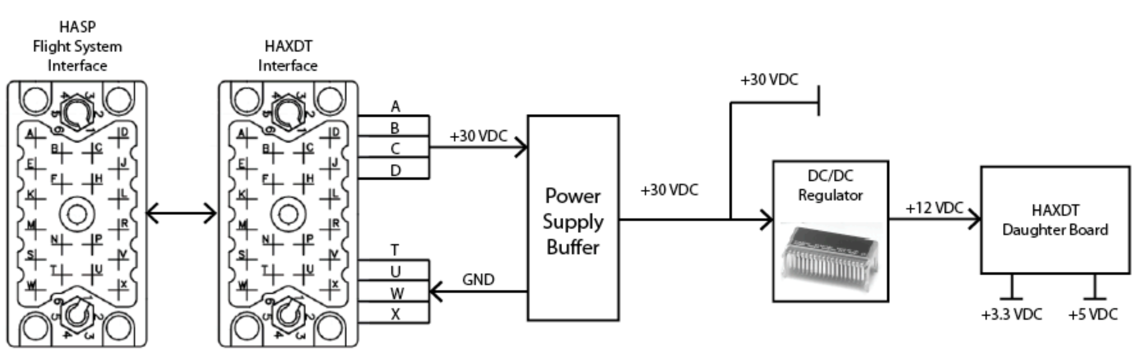

Figure 1. Power system connections showing interface with the HASP flight system and all foreseen voltage lines.

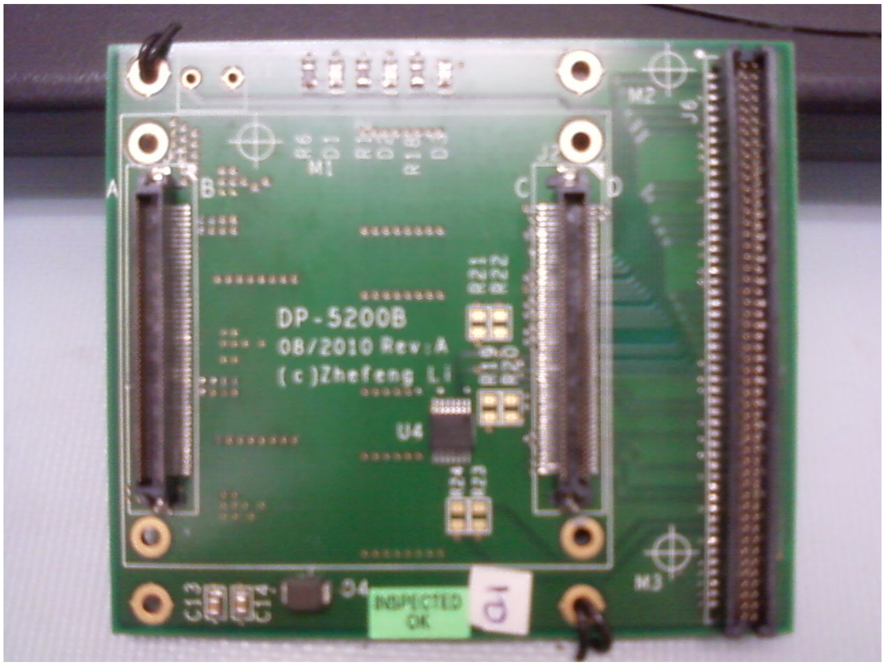

Figure 2. UMN UAV group daughterboard.

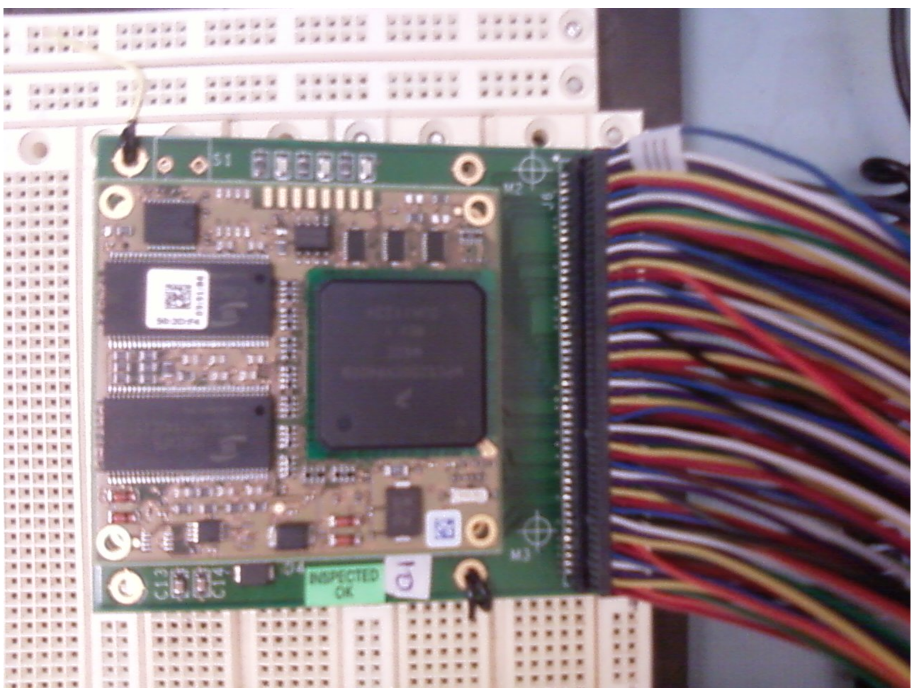

Figure 3. Flight computer mounted on daughterboard with wiring harness attached. The harness is used to connect to all devices and transmit data via the RS-232 serial interface with the HASP flight system.

References

1. Aerospace Engineering and Mechanics UAV Research Group website
URL: http://www.uav.aem.umn.edu/