HASP Student Payload Application for 2023

Payload Title: VHF-Band Video-Streaming Payload		
Institution: Gannon University		
Payload Class (Enter SMALL, or LARGE):		Submit Date: 1/6/2023

Project Abstract:

The proposed payload for HASP 2023 will conduct experiments to test the range of a new VHF-band transmitter at 144 MHz for real-time video streaming as well as the overall functionality of the video streaming payload with the new transmitter. Also, as part of the effort, the Gannon team also desires to learn the procedure to get necessary approval for experimental use of the licensed VHF band in order to properly conduct future experiments with a smaller-scale 2000g high-altitude balloon system. Toward achieving the goals, more specific objectives are 1) to configure a battery-operating Windows 10-based computer having at least one PCIe slot and integrate with the VHF modulator for video streaming at an average data rate of 4.8 Mbps; 2) to design a VHF front-end system to amplify the VHF modulator output by an average power-gain of 24dB; and 3) to estimate the 144 MHz radio range of the VHF transmitter with an average transmission power of 24 dBm (0.251 watts).

Team Name: Gannon University		Team or Project Website: N/A
	Student Leader Contact Information:	Faculty Advisor Contact Information:
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The signature below indicates that the student lead and faculty advisor have read and understood the HASP CFP and Student Payload Interface manual, commit to providing the required HASP deliverables by the indicated due dates and agree to respond to HASP management inquires in a timely manner.

Commitment Signature:	Andrew Snowdy	Wookwon Lee

Flight Hazard Certification Checklist

NASA has identified several classes of material as hazardous to personnel and/or flight systems. This checklist identifies these documented risks. Applying flight groups are required to acknowledge if the payload will include any of the hazards included on the list below. Simply place an (x) in the appropriate field for each hazard classification. **Note:** Certain classifications are explicitly banned from HASP and the remaining hazards will require additional paperwork and certifications. If you intend to include one of the hazards, you must include detailed documentation in section 3.8 of the application as required by the HASP Call for Payloads.

This certification must be signed by both the team faculty advisor and the student team lead and included in your application immediately following the cover sheet form.

Hazardous Materials List		
Classification	**Included on Payload**	**Not Included on Payload**
RF transmitters	X	
High Voltage		X
Lasers (Class 1, 2, and 3R only) Fully Enclosed		X
Intentionally Dropped Components		X
Liquid Chemicals		X
Cryogenic Materials		X
Radioactive Material		X
Pressure Vessels		X
Pyrotechnics		X
Magnets less than 1 Gauss*		X
UV Light		X
Biological Samples		X
Non-Rechargeable Batteries		X
Rechargeable Batteries		X
High intensity light source		X

* Magnets greater than 1 gauss are banned.

Student Team Leader Signature: Andrew Snider

Faculty Advisor Signature: Wookhan Lee

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1. Payload Description

Over the past few years, Gannon University has developed a functional prototype of a real-time video streaming system employing several Raspberry Pis plus Pi cameras and a pair of all-standard VHF/UHF/L-band modulator[1] and demodulator[2]. While testing was performed in a lab setting via a coaxial cable to connect the modulator and demodulator, Gannon University desires to test this video streaming system over the VHF spectrum band for application to future high-altitude balloon flights, including one for the 2024 total solar eclipse. The primary goals of this payload on the HASP2023 will be 1) to test functionality in the extreme weather conditions of high-altitude ballooning and 2) to test the radio range at a VHF band of ~144 MHz utilizing an 8 MHz bandwidth for real-time video streaming.

1.1 Payload Scientific / Technical Background

During the August 2017 total solar eclipse, Gannon University successfully conducted an experiment for real-time video streaming with four Raspberry Pis plus four Pi cameras via a single wireless link between a pair of 5.8 GHz Rocket M5 modems[3]. The real-time video streaming lasted about 7 minutes right before and after the 2017 total solar eclipse before the radio connection was lost between the payload and the ground station that was fixed at the balloon launch site. From this experience, we desire to substantially extend the radio range between the payload and the fixed ground station to extend the time duration of video streaming between them. We found a pair of VHF-band modems that can support the required data rates for video streaming. In our ballpark estimate, since the radio range is inversely proportional to the square of the carrier frequency (i.e., transmission distance ~ $1/f^2$), compared to the 5.8 GHz modem, this new modem operating at 144 MHz thus having a frequency ratio of 5.8GHz/0.144GHz = 40 would extend the radio range by 1600 times for the same transmit power. If the M5's radio range were, say 1 mile, then this new modem would be able to theoretically extend the radio range to 1600 miles between the payload and the fixed ground station.

1.1.1 Mission Statement

On HASP2023, the Gannon team desires to test the range of the proposed 144MHz transmitter[1] for real-time video streaming as well as testing the overall functionality of its video streaming payload. The team also desires to learn the procedure to get necessary approval for experimental use of the licensed VHF band in order to properly conduct future experiments with a smaller-scale 2000g high-altitude balloon system.

1.1.2 Mission Background and Justification

Our payload design utilizing the 5.8 GHz M5 modems during the 2017 solar eclipse was described and disseminated at the Academic High-Altitude Conference (AHC) 2017[4]. The 5 GHz modem M5 used in 2017 was set for a data rate of 4.8 Mbps with a line-of-sight range estimated to be about 20 miles. A direct line of sight of 20 miles is considered a relatively short radio range in high-altitude ballooning even for balloon tracking purposes. For this data rate, the M5 transmit power required was 24 dBm (0.251 watts)[3].

In a continuing effort to advance the video streaming capability, the Gannon ballooning team has explored and developed a multi-streaming real-time video streaming system that utilizes a pair of VHF transmitter[1] and receiver[2]. Its design and potential application to e-health interventions in isolated rural areas were described and disseminated at the IEEE Global Humanitarian Technology Conference (GHTC) 2020[5]. This system was intended as an overlay over the 140~148 MHz frequency band for cost effective, long-range, high-data-rate wireless communication in remote rural areas, hoping for necessary changes in the current worldwide frequency spectrum regulations, especially in the intended geographical regions where the licensed VHF bands would be rarely used by handheld amateur mobile (HAM) radio users. Due to the constraints on the licensed VHF bands, all testing of the proposed prototype was conducted only in the lab setting via a coaxial cable.

One of the inherent advantages of the 2-meter VHF-band radios for real-time video streaming is the substantially extended coverage range compared to any other radio systems operating over the unlicensed Industrial, Scientific, and Medical (ISM) bands (i.e., 900MHz, 2.4 GHz, or 5.8 GHz). Based on the preliminary information gathered so far including some discussions with the HASP team members, it is believed that the HASP2023 campaign would offer an excellent opportunity to test our only-lab-tested VHF-band video streaming system in a real-world wireless transmission scenario and high-altitude ballooning.

1.1.3 Mission Objectives

Toward achieving the primary goals of our payload on the HASP2023, the specific objectives of our payload are as follows:

1) To integrate a Windows 10-based computer capable of operating off battery power and having at least one PCIe slot with a DTA-2115B VHF modulator for video streaming at an average data rate of 4.8 Mbps.
2) To design a VHF front-end system that can amplify the DTA-2115B VHF output by an average power-gain of 24dB since the DTA-2115B VHF output is limited to 0 dBm.
3) To estimate the operational range of the 144 MHz DTA-2115B modulator with an average transmission power of 24 dBm (0.251 watts).

One of the anticipated challenges for the success would be a proper thermal control of the DTA-2115B as its operation temperature is 0 ~ 45 degrees in Celsius[6] and is fan cooled.

1.1.4 Scientific Relevance to the HASP Platform

Over the past decades, various technical approaches have been proposed for high-data-rate wireless links suitable for video conferencing for which a data rate of a few megabits per second is desired. For instance, an integration of VSAT with WiMAX technologies[7] is discussed for rural areas in which high-data-rates are accommodated by WiMAX and its coverage areas is extended via the VSAT infrastructure. Mobile WiMAX is evaluated for medical ultrasound streaming[8] which requires diagnostic quality of the transmitted medical images. The WiMAX broadband connectivity is discussed [9] as a cost-effective means of delivering e-health/telemedicine in rural areas.

To address the technical challenges for long-range communication we propose a 2-meter VHF radio system as an overlay over the 144 MHz frequency band for long-range wireless communication for possible application to high-altitude ballooning. The 144 MHz VHF band operation is attractive from the deployment standpoint due to the compact size of needed radios and antennas, while effectively facilitating long range communication. An 8 MHz bandwidth is desired to achieve high-data-rate transmission suitable for video streaming in real time.

The existing VHF-band broadband services and systems are mostly for terrestrial operations. For high-altitude ballooning, our attempt to do real-time video streaming over an 8 MHz bandwidth is relatively new. A successful verification of our long-range video-streaming payload may lead to further advances in relevant technology development and applications for other scientific exploration such as environmental monitoring with real-time videos as well as our near-term interest in video steaming during the 2024 total solar eclipse.

1.2 Payload Systems and Principle of Operation

Figure 1 shows a high-level description of our payload comprised of 1) two video sources, 2) one Ethernet switch, 3) one i5 computer, 4) DTA 2115B VHF modulator, and 5) VHF power amplifier. These components are further explained in detail in sections 1.3, 1.4, 1.5 and 1.6.

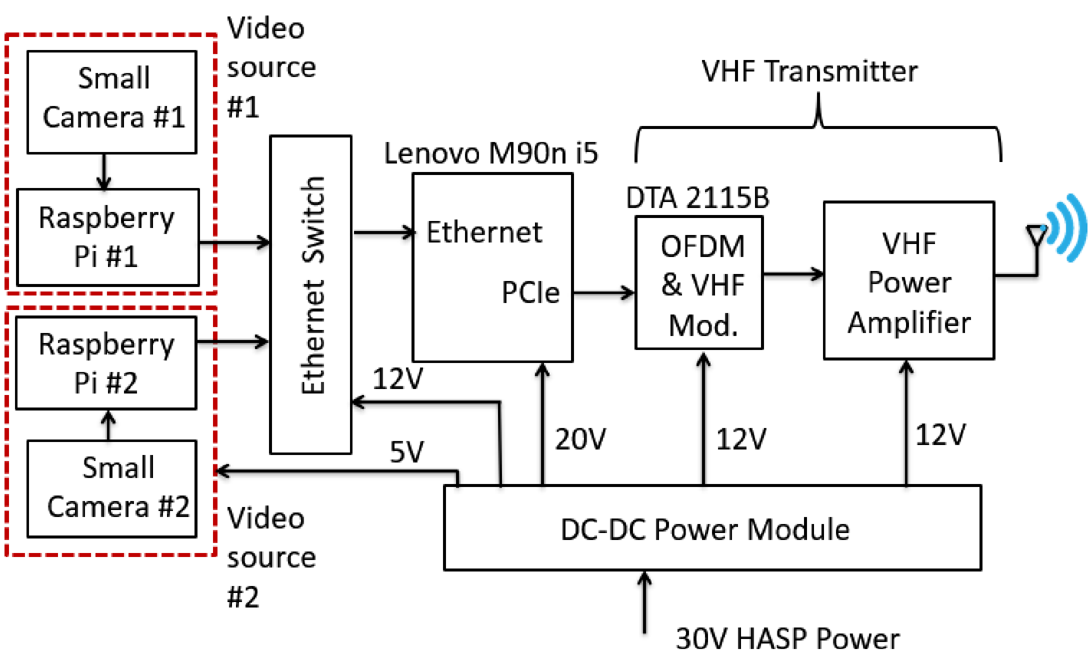


Figure 1. Block diagram of the proposed VHF-band video streaming payload

1.3 Major System Components

1) **Video sources**: Two Raspberry Pis will be used to output UDP packets for real-time video. Each Raspberry Pi is assigned a static IP address, e.g., 192.168.1.x, and integrates one Pi-camera. The Pi-camera is connected to the Pi-camera serial interface slot available on the Raspberry Pi (version 3, Model B). For data communication, each Raspberry Pi is connected to an Ethernet switch via a category-6 flat Internet network cable with RJ45 connectors on both ends.

2) **Ethernet switch**: The Ethernet switch facilitates multiplexing of the two real-time video streams allowing data flow from two Raspberry Pis to the Lenovo M90n i5-PC. The Ethernet switch[10] we have chosen supports five 10/100/1000 Base-T Ethernet ports and thus each port is compatible with the 10/100 Base-T Ethernet port available on the Raspberry Pi board. Its temperature range is -40° ~ 167°F (-40° to 75°C) and thus suitable for near-space exploration.

3) **Lenovo M90n i5 computer**: This computer operates the software needed for DTA 2115B which processes UDP packets from the video sources to broadcast to more than one end-user (i.e., destination). For the payload, we have chosen a Lenovo ThinkCentre M90n nano i5. An i5 CPU is sufficient for the payload as, in our lab testing of the DTA 2115, we had used a pair of i5 desktop computers to successfully operate the VHF modulator and demodulator for the intended video streaming.

4) **DTA 2115B VHF modulator**: The DTA-2115B[1] is DekTec's highest-end modulator on a PCIe gen 3x1 card. It is a general-purpose modulator for generating virtually any cable, terrestrial, and satellite modulation standard currently in use around the world. This modulator in our payload will generate its output per the ATSC 3.0 standard originally intended for television broadcasting and created by the Advanced Television Systems Committee (ATSC).

5) **VHF power amplifier**: This component is to amplify the DTA 2115B signal to transmit at a power level of 24 dBm which was the transmit power level previously used with our 5.8 GHz Rocket M5 modem in 2017. To compare its radio range, we intend to use the same transmit power level of 24 dBm with the 144MHz VHF-band operation. We have chosen Fairview Microwave's SPA-030-27-01-SMA[11] which is a broadband multi-octave RF 1W power amplifier operating in the 20 MHz to 3 GHz frequency range and over the temperature range of -40° to 75°C. This amplifier offers 30 dBm of P1dB and 27 dB small signal gain which is a good fit for our intended 24 dB amplification from the maximum power level of 0 dBm of the DTA 2115B output signal.

6) **DC-DC power module**: This is a set of DC-DC converters to supply the necessary power to the other payload components as indicated in Figure 1 (i.e., two 5V outputs and four 12V outputs).

1.4 Mechanical and Structural Design

The mechanical enclosure for the payload is shown in Figure 2. The entire payload will be assembled on an aluminum plate cut to the dimensions of the large payload class. Each mechanical structure will be attached to both plates using steel bolts inserted into through holes and secured on the bottom with a hex nut and lock washer. Electronic stacks will be connected using aluminum standoffs attached with machine screws and lock washers. The top and sides of the payload enclosure will be made of sheet aluminum, which attaches to the bottom plate via angled brackets and machine screws.

The various electronic components will be mounted using either bent aluminum strips or 3D printed ABS mounting brackets. All images of the electronic components are provided in Appendix A except for the Power Module whose image is unavailable at the time of preparing this proposal.

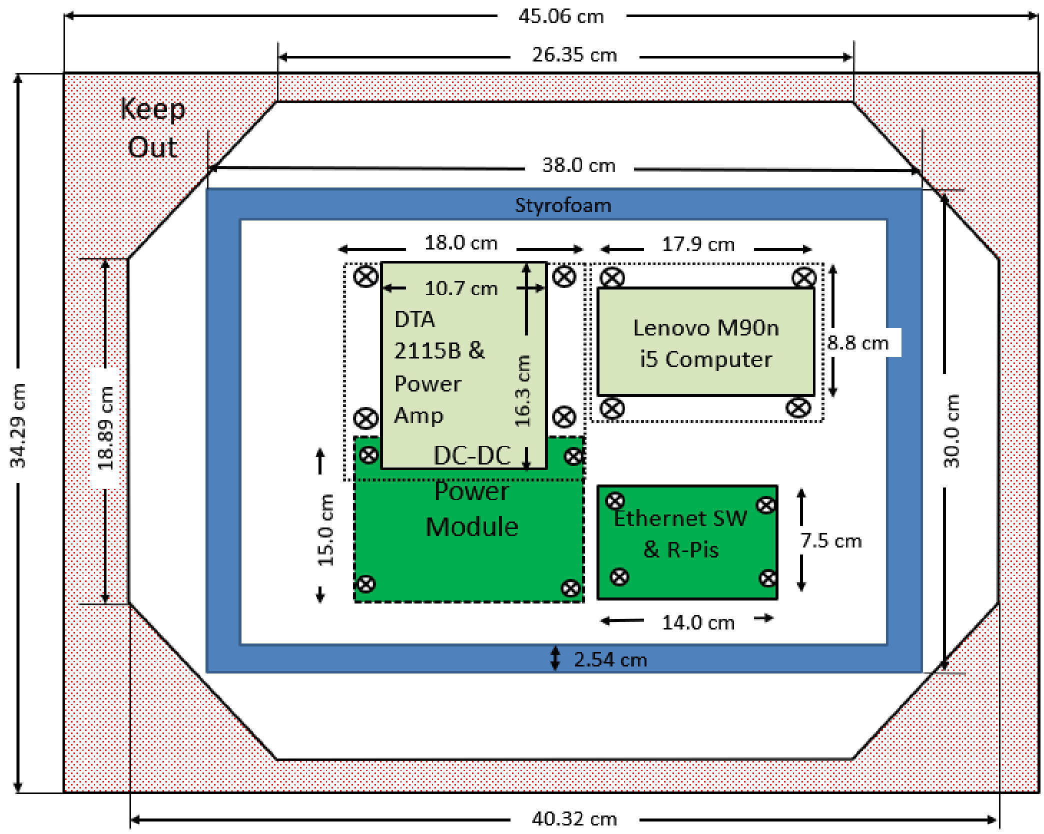


Figure 2. Top view of mechanical enclosure showing location of major electrical and mechanical elements

1.5 Electrical Design

A preliminary electrical schematic diagram is shown in Figure 3. The output voltage from the 30 VDC power supply provided by HASP could vary from ~28 (or even lower) to ~34 VDC over the flight. To cope with these variations, several DC-DC converters will be used to supply the regulated DC voltages required by our on-board electronics, i.e., +12V and +5V. These DC-DC converters will be selected to operate over the wide range of input voltages covering the voltage variation mentioned above.

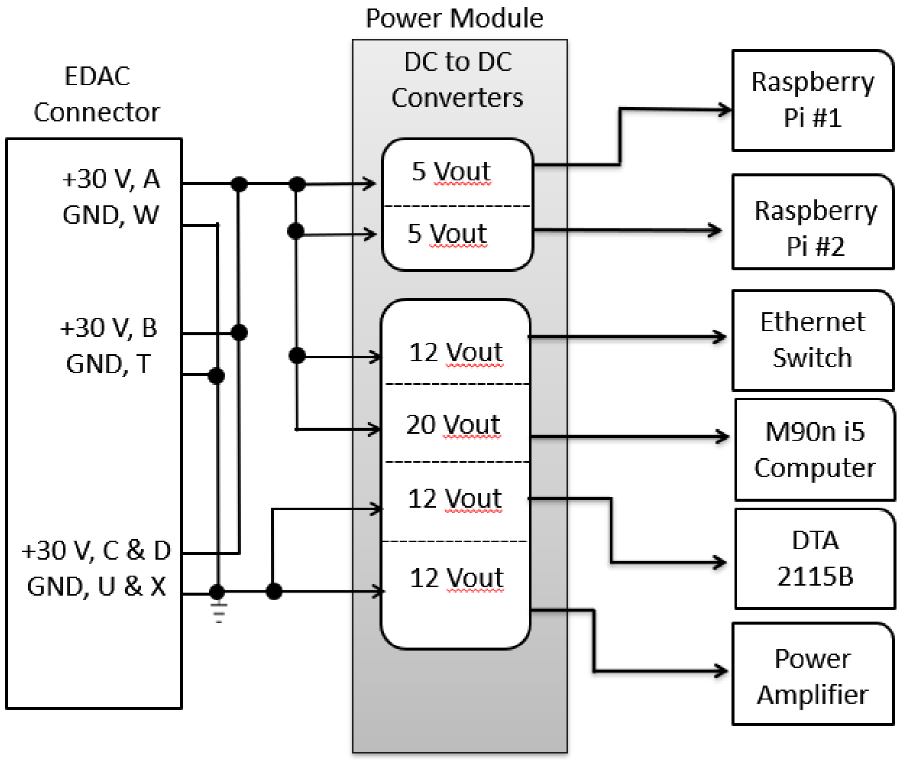


Figure 3. Electrical circuit diagram of the EDAC pins and the primary voltage conversion components

1.6 Thermal Control Plan

The following list is a summary of operation temperatures of the electronic components in the payload:

1. Raspberry Pi: the CPU is qualified from -40°C to 85°C and the LAN is qualified from 0°C ~ 70°C (see https://copperhilltech.com/content/The%20Operating%20Temperature%20For%20A%20Raspberry%20Pi%20%E2%80%93%20Technologist%20Tips.pdf)
2. Ethernet switch: -40°C to 75°C (see [10])
3. Lenovo M90n Nano: MIL-STD-810H passed (i.e., -33°C ~ 63°C) (see [12] and https://www.trentonsystems.com/blog/mil-std-810-temperature-testing)
4. DTA 2115B: 0°C ~ 45°C (see [6])
5. Power amplifier: -40°C ~ 75°C (see [11])

The Raspberry Pi's CPU and Ethernet switch are properly rated for high-altitude ballooning and have been verified to operate successfully on the past on HASP or on the 2017 eclipse flight. Although the minimum operation temperature of the LAN9512 (for USB and Ethernet IC) of Raspberry Pi is not rated for high-altitude ballooning, we had observed in our 2017 eclipse balloon flight that each of four Raspberry Pis with a webcam connected to a USB port properly recorded and saved the webcam video to an SD card for the entire balloon flight in a typical Styrofoam payload.

The DTA 2115B operating temperature is not rated for high-altitude ballooning. However, as it generates a good amount of heat during operation, we expect that the minimum operation temperature could be much lower than 0°C and this is one of the test points while flying on HASP as it will help us to determine up to what altitudes it will operate in consideration of future high-altitude balloon flights. Of more concern will be the upper thermal limit, which will require a substantial heatsink and possibly the use of a Peltier cooler.

The Lenovo M90n i5 computer is rated for high-altitude ballooning. It is expected to function properly during flight.

As a general thermal control plan, there will be a layer of Styrofoam lining the inside walls of the frame to provide a source of thermal insulation that is easy to shape and mold. Electronic components with high power consumption will be heat-strapped to the aluminum base plate using stranded copper wire to control reaching to excessively high temperatures to some extent.

2. Team Structure and Management

2.1 Team Management

See subsections 2.2 ~ 2.4.

2.2 Team Organization and Roles

The current team consists of six undergraduate students under the guidance of two faculty advisors. The anticipated responsibilities of student team members are outlined below and are assigned primarily based on individual competencies. However, all student team members are responsible for a project success and thus, it is expected that students will also help with activities that fall outside the scope of their primary responsibilities.

Student	Position	Concentration	Email
Andrew Snowdy	Project Lead – Lenovo M90n i5 PC integration and transmission for video streaming	Electrical Engineering (Junior)	snowdy001@gannon.edu
Kalkidan Lakew	Video source operation and integration; power module design	Electrical Engineering (Junior)	lakew001@gannon.edu
Hannah Jacobs	VHF front-end design and integration	Electrical Engineering (Freshman)	jacobs014@gannon.edu
Zoey McClain	VHF modulator operation and integration	Electrical Engineering (Freshman)	mcclain009@gannon.edu
Sara Jones	VHF receiver operation and testing	Cyber Engineering (Freshman)	jones167@gannon.edu
John White	Desktop i5 PC integration and reception for video streaming	Cybersecurity (Sophomore)	white070@gannon.edu

Faculty Member	Position	Concentration	Email and Phone
Dr. Wookwon Lee	Advisor	Electrical & Cyber Engineering	lee023@gannon.edu 814-871-7630
Dr. Nicholas Conklin	Co-advisor	Physics	conklin003@gannon.edu 814-871-7740

All team members will be considered for participation in the integration at CSBF and/or flight operations at Ft. Sumner depending on their availability. There are currently two foreign nationals: Hannah Jacobs from South Africa and Kalkidan Lakew from Ethiopia.

To enhance student members' learning experience in technical, leadership, and project skills, mentoring and training of these students will be facilitated through lab activities of ~5 hours/week on average under close in-lab supervision of the two faculty members. Dr. W. Lee in collaboration with Dr. N. Conklin will manage team finances and lead the efforts for student team development, payload definition, design, and development in order to hit all the HASP deliverables and milestones by the due dates.

2.3 Timeline and Milestones

As this project is a continuation of our previous development effort, our tentative timeline and milestones are as follows:

- Design of payload modules (1/9/2023–2/10/2023, 5 weeks): complete revision and unit testing of individual system modules.
  Deliverables: internal; working system modules ready for in-lab integration & test

- Module integration (2/13/23–3/17/23, 5 weeks): complete integration of all modules into a payload and integration testing.
  Deliverables: completed integration and internal documentation for review

- Construct payload enclosure and any revision necessary (3/20/23–4/21/23, 5 weeks): complete payload construction.
  Deliverables: Payload Specification and Integration Plan (PSIP). Submit a preliminary PSIP by 4/28/23.

- Submit Preliminary PSIP Document: April 28, 2023
- Submit NASA Integration Security Document (for integration at CSBF): April 28, 2023
- On-campus preparation (5/15/2023– 6/30/2023): complete any necessary revision/refinement of the modules and payload; assemble the payload onto the HASP plate; travel arrangement for student members.
  Deliverables: complete payload, ready to go; complete Final PSIP.

- Submit Final PSIP Document: June 30, 2023
- Submit NASA Flight On-Site Security Document (for launch at Ft. Sumner): June 30, 2023
- Submit Final FLOP Document: July 21, 2023

- Student payload integration at CSBF, Palestine, TX: July 24 – July 28, 2023
  Payload integration & Thermal & Vacuum Tests toward a flight-ready payload

- HASP flight preparation (TBD): August 28 – Sept 02, 2023
- HASP launch and flight operations (TBD): September 03~04, 2023
- Submit Final Flight/ Science Report: December 08, 2023

2.4 Anticipated Participation in Integration and Launch operations

Our preliminary plans for participation in both payload integration and testing at CSBF, Palestine, TX, and HASP launch operations at Ft. Sumner, NM are to have one faculty advisor and 2~3 student team members for each event.

3. Payload Interface Specifications

3.1 Weight Budget

Due to the amount of current needed to operate the electronic components, we are applying for the large payload class with an upper mass limit of 20 kg, as specified in the Call for Payloads. Mass estimates for all payload components are provided in Table 1, and the payload will easily stay under the mass limit.

Table 1. Payload Components Mass

Item	Mass	Uncertainty	Comments
Raspberry Pis (2 units)	42g x 2 = 84 g	+-2%	Per datasheet
Ethernet Switch	50 g	+-5%	Without case, educated guess
Lenovo M90n i5 Computer	505g	+-10%	Nominal weigh from datasheet
DTA 2115B Modulator	325 g	+-2%	Per datasheet
VHF Power Amplifier	46.27 g	+-2%	Per datasheet
Power Module	300 g	+-10%	Educated guess
Payload enclosure	400 g	+-10%	Educated guess
TOTAL	1.710 kg (3.77 lbs)	+-10%	

3.2 Power Budget

Table 2. Payload Power Budget

Item	Voltage^{+}	Current	Power (W)	Comments
Raspberry Pis (2 units)	3.7V	0.7A*2=1.4A	2.59W*2= 5.18W	Measured during video streaming
Ethernet Switch	3.9V	0.509A	1.98W	Measured during normal operation
Lenovo M90n Nano i5	20V	1.625A	32.5W^{++}	For light usage; 50% usage assumed of

				max. 65W power AC-DC adapter for M90n
DTA 2115B Modulator	12V	1.5A	18W	From datasheet
VHF Power Amplifier	12V	0.220A	2.64W	From datasheet to produce transmit power @24dBm
Power Module	30V	--	--	82% efficiency assumed for the total wattage
TOTAL	30V	2.01A (/82% = 2.45A)	60.3W (/82% = 73.5W)	

+ Power supply voltage applied to the DC-DC converter input
++ This estimate is somewhat optimistic.

3.3 Downlink Serial Data

No downlink serial data is requested.

3.4 Uplink Serial Commanding

No uplink serial commanding is requested.

3.5 Analog Downlink

No analog downlink is requested.

3.6 Discrete Commanding

No analog downlink is requested.

3.7 Payload Location and Orientation Request

No payload seat preference is requested.

3.8 Special Requests

3.8.1. Use of an RF transmitter

Use of RF transmitter at the HAM band is requested for experimental purposes to assess the radio range of the proposed VHF modulator, DTA-2115B[1],[6], for establishment of a long-range wireless video streaming capability with DTA-2115B as shown in Figure 1. DTA-2115B's maximum RF output is 0 dBm while the desired transmit power for the payload under test is 24 dBm. As such, a power amplifier will be used and SPA-030-27-01-SMA[11] from Fairview Microwave is selected. Further details can be found in their datasheets[6],[11], respectively. For a summary of the proposed RF transmission, please see Appendix B.1 Radio Frequency Transmitter Hazard Documentation.

4. Preliminary Drawings and Diagrams

Figures 1~3 above represent all key aspects of the payload design and operation.

5. References

[1] DekTec, *DTA-2115B, All-standard VHF/UHF/L-band Modulator for PCIe*. [online] https://www.dektec.com/products/PCIe/DTA-2115B/.

[2] DekTec, *DTA-2131, Multi-standard cable/terrestrial Receiver for PCIe*. [online] https://www.dektec.com/products/PCIe/DTA-2131/.

[3] Ubiquiti, *Rocket(R) M5, 5Ghz Carrier Class airMax Basestation*. [online] https://dl.ubnt.com/datasheets/rocketm/RocketM_DS.pdf

[4] T. Batjargal, W. Lee, and N.B. Conklin, "Implementation of simultaneous multi-streaming of live solar eclipse video via 5.8 GHz AirMax," in *Proc. the 8th Annual Academic High-Altitude Conference*, University of Minnesota – Twin Cities, October 27-28, 2017.

[5] W. Lee, M. Altamimi, J.P. Arockia Doss, O.M. Salameh, R.T. Bryan Rivera, and N.B. Conklin, "Proof-of-concept prototype of wideband VHF-based video streaming for e-health interventions in remote rural areas," in *Proc. 10th IEEE Global Humanitarian Technology Conference*, Seattle, WA, Oct 29 –Nov 01, 2020.

[6] DekTec, DTA-2115B All-Standard, All-Band Modulator, datasheet, Sept. 2022. [online] https://www.dektec.com/products/PCIe/DTA-2115B/downloads/DTA-2115B%20Datasheet.pdf

[7] Y. and J. Soar, "Integration of VSAT with WiMAX technology for e-health in Chinese rural areas," in *Proc. International Symposium on Computer, Communication, Control and Automation (3CA)*, 2010, pp. 454-457.

[8] A. Alinejad, N. Philip, and R.S.H. Istepanian, "Performance analysis of medical video streaming over mobile WiMAX," in *Proc. Annual International Conference of the IEEE Engineering in Medicine and Biology*, Buenos Aires, Argentina, August 31 - September 4, 2010, pp. 3471-3474.

[9] K. Chaudhari and P.T. Karule, "WiMAX network-based e-health service and telemedicine applications for rural and remote populations in India," in *Proc. International Conference on Medical Imaging, m-Health and Emerging Communication Systems (MedCom)*, 2014, pp. 398-406.

[10] B&B Electronics Mfg. Co. Inc., ELNIX Industrial Ethernet Switch EIR405-T: User Manual, Doc. Number: EIR405-T – 0912m, 2008.

[11] Fairview Microwave, SPA-030-27-01-SMA: Medium Power GaAs Amplifier at 1 Watt P1dB Operating from 20 MHz to 3 GHz with 39 dBm IP3, SMA Input, SMA Output and 27 dB Gain, 2019. [online] https://www.fairviewmicrowave.com/images/productPDF/SPA-030-27-01-SMA.pdf.

[12] ThinkCentre M90n-1 Nano Platform Specifications, 2020. [online] https://www.lenovoshop.sk/import/soubory/M90n-1%20Nano%20Platform%20Specification.pdf.

Appendix A

Appendix A.1 Detailed electrical drawings not required in previous sections

None

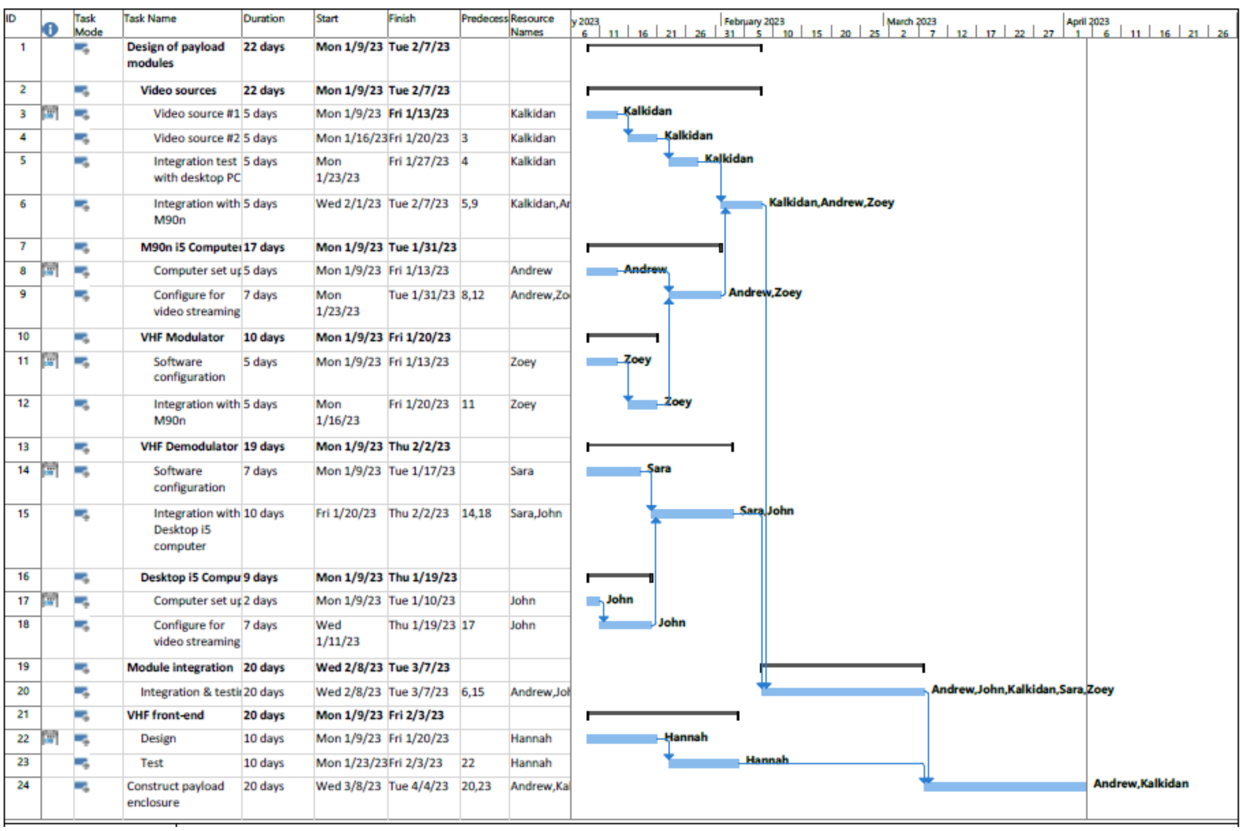
Appendix A.2 Detailed mechanical drawings not required in previous sections

None

Appendix A.3 Detailed timeline and milestone WBS document

The following Gantt chart shows the detailed timeline and milestones for payload development efforts mentioned in subsection 2.3, i.e.,

- o Design of payload modules (1/9/2023–2/10/2023, 5 weeks)
- o Module integration (2/13/23–3/17/23, 5 weeks)
- o Construct payload enclosure and any revision necessary (3/20/23–4/21/23, 5 weeks)



ID	Task Mode	Task Name	Duration	Start	Finish	Predecess	Resource Names
1		**Design of payload modules**	**22 days**	**Mon 1/9/23**	**Tue 2/7/23**		
2		**Video sources**	**22 days**	**Mon 1/9/23**	**Tue 2/7/23**		
3		Video source #1	5 days	Mon 1/9/23	Fri 1/13/23		Kalkidan
4		Video source #2	5 days	Mon 1/16/23	Fri 1/20/23	3	Kalkidan
5		Integration test with desktop PC	5 days	Mon 1/23/23	Fri 1/27/23	4	Kalkidan
6		Integration with M90n	5 days	Wed 2/1/23	Tue 2/7/23	5,9	Kalkidan,Ar
7		**M90n i5 Compute**	**17 days**	**Mon 1/9/23**	**Tue 1/31/23**		
8		Computer set up	5 days	Mon 1/9/23	Fri 1/13/23		Andrew
9		Configure for video streaming	7 days	Mon 1/23/23	Tue 1/31/23	8,12	Andrew,Zo
10		**VHF Modulator**	**10 days**	**Mon 1/9/23**	**Fri 1/20/23**		
11		Software configuration	5 days	Mon 1/9/23	Fri 1/13/23		Zoey
12		Integration with M90n	5 days	Mon 1/16/23	Fri 1/20/23	11	Zoey
13		**VHF Demodulator**	**19 days**	**Mon 1/9/23**	**Thu 2/2/23**		
14		Software configuration	7 days	Mon 1/9/23	Tue 1/17/23		Sara
15		Integration with Desktop i5 computer	10 days	Fri 1/20/23	Thu 2/2/23	14,18	Sara,John
16		**Desktop i5 Compu**	**9 days**	**Mon 1/9/23**	**Thu 1/19/23**		
17		Computer set up	2 days	Mon 1/9/23	Tue 1/10/23		John
18		Configure for video streaming	7 days	Wed 1/11/23	Thu 1/19/23	17	John
19		**Module integration**	**20 days**	**Wed 2/8/23**	**Tue 3/7/23**		
20		Integration & testi	20 days	Wed 2/8/23	Tue 3/7/23	6,15	Andrew,Jol
21		**VHF front-end**	**20 days**	**Mon 1/9/23**	**Fri 2/3/23**		
22		Design	10 days	Mon 1/9/23	Fri 1/20/23		Hannah
23		Test	10 days	Mon 1/23/23	Fri 2/3/23	22	Hannah
24		Construct payload enclosure	20 days	Wed 3/8/23	Tue 4/4/23	20,23	Andrew,Kal

Figure 4. Gantt chart for payload development phase

Appendix A.4 Additional images of existing components

Figure 5 shows the images of the components depicted in Figure 1.

(a) Raspberry Pi with a Pi-cam

(b) Ethernet switch with case (the case will be removed for the payload)

(c) Lenovo ThinkCentre M90n Nano i5

(d) DTA-2115B VHF modulator

(e) Power amplifier

(f) VHF dipole antenna

Figure 5. Images of payload electronic components

Appendix A.5 Preliminary PCB layouts

None

Appendix B: NASA Hazard Tables

Appendix B.1 Radio Frequency Transmitter Hazard Documentation

HASP 2022 RF System Documentation	
Manufacture Model	DTA
Part Number	2115B
Ground or Flight Transmitter	Flight Transmitter (for broadcasting)
Type of Emission	C7W
Transmit Frequency (MHz)	32 ~ 999 MHz (on HASP 2023, 2-meter 144 MHz HAM band transmission is preferred)
Receive Frequency (MHz)	Not applicable (only broadcasting from the payload)
Antenna Type	Half-wave length VHF dipole antenna (~38”)
Gain (dBi)	~2.15 dBi (nominal for any half-wave length dipole antenna)
Peak Radiated Power (Watts)	0.5W (27 dBm)
Average Radiated Power (Watts)	0.25W (24 dBm)

Appendix B.2 High Voltage Hazard Documentation – N/A

HASP 2022 High Voltage System Documentation	
Manufacture Model	
Part Number	
Location of Voltage Source	
Fully Enclosed (Yes/No)	
Is High Voltage source Potted?	
Output Voltage	
Power (W)	
Peak Current (A)	
Run Current (A)	

Appendix B.3 Laser Hazard Documentation – N/A

HASP 2022 Laser System Documentation			
Manufacture Model			
Part Number			
Serial Number			
GDFC ECN Number			
Laser Medium			
Type of Laser			
Laser Class			
NOHD (Nominal Ocular Hazard Distance)			
Laser Wavelength			
Wave Type		*(Continuous Wave, Single Pulsed, Multiple Pulsed)*	
Interlocks		*(None, Fallible, Fail-Safe)*	
Beam Shape		*(Circular, Elliptical, Rectangular)*	
Beam Diameter (mm)		**Beam Divergence (mrad)**	
Diameter at Waist (mm)		**Aperture to Waist Divergence (cm)**	
Major Axis Dimension (mm)		**Major Divergence (mrad)**	
Minor Axis Dimension (mm)		**Minor Divergence (mrad)**	
Pulse Width (sec)		**PRF (Hz)**	
Energy (Joules)		**Average Power (W)**	
Gaussian Coupled (e-1, e-2)		*(e-1, e-2)*	
Single Mode Fiber Diameter			
Multi-Mode Fiber Numerical Aperture (NA)			
Flight Use or Ground Testing Use?			

Appendix B.4 Battery Hazard Documentation – N/A

HASP 2022 Battery Hazard Documentation	
Battery Manufacturer	
Battery Type	
Chemical Makeup	
Battery modifications	*(Must be NO)*
UL Certification for Li-Ion	
SDS from manufacturer	
Product information sheet from manufacturer	