Changes made since Proposal

1. Changes made to Vehicle Criteria

   The vehicle has changed in overall size and thrust requirements. The initial sizing for the launch vehicle was 1270 mm to 1350 mm. The current length is 3048.0 mm (120 inches, 10 feet). The diameter was initially planned for 120 mm and is still planned to be the same. The length was increased drastically due to CG and CP calculations based on the payload achieving the target altitude of 5280 feet. The initial calculations made the rocket very unstable and ultimately un-flyable. The plan for dual parachutes is still in use at this point.

2. Changes made to Payload Criteria

   At this point, no changes have been made to the payload items. All items presented in the proposal are part of the current plan.

3. Changes made to Activity Plan

   The following changes have been made to the Activity Plan:

   a. Water tunnel testing moved from Nov 15-20 to Jan 6-12 due to PIV equipment issues

   b. Electrical testing has been completed on the GPS/Transmitter/Receiver but has not been completed on the Sensors for CO/Temp because they have not been delivered yet.

   c. Rocket body build has been postponed from Dec 1-31 to Dec 15-Jan 15 because the mandrels have not been finished.

Team Members

Brandon W.	Student Team Project Manager
Chris C.	Student Team Project Asst. Manager
Darrian D.	Electrical/Science Team Lead
Adrian G.	Electrical/Science team member
James D.	Mechanical Department Team Lead
Lumumba O.	Structures Team Lead
Raquel F.	Structures team member
Angelo A.	Structures team member
Chris H.	Structures team member

Vehicle Criteria

1. Mission Statement

   The mission of the TULIP rocket is to carry a scientific payload to a target altitude of 5,280 feet (1.609 kilometers). The structure must be strong enough to withstand the forces of launch, protect the payload, and ensure stable trajectory and recovery for future missions. The design should be such that the rocket is stable enough to provide true trajectory, but not excessively stable so that the rocket turns into the wind and flies horizontal prior to apogee.

   The scientific payload will look at the surface temperature, humidity, dew point, and Carbon Monoxide levels in the atmosphere as well as wind speed from apogee to landing. These are some of the primary items that would be looked at on distant planets to give us a good indication of the inhabitability. Our design is to make the systems rugged but inexpensive and easy to retrieve the data once collected.

2. Requirements

d.

and transportation of all motors. All motors will be ordered through him and are all commercially available.

j. *Each team shall be responsible for providing their launch equipment if possible, especially if using hybrid motors. The Huntsville Area Rocketry Association (HARA) has launch assets (controller, pads) that can be used for APCP rocket launches and has limited hybrid capability.* At this point, no hybrid motors are part of the trade studies and are not part of the consideration process. The team will use conventional APCP motors.

k. *All teams, including hybrid motor teams, must launch their full scale rocket prior to launch day, as a test. The purpose is to test the vehicle structural and recovery systems. A sub-scale motor could be used for the flight tests.* Tests will be conducted as soon as plausible in the Dec-Jan timeframe. They will be launched at the Samson, AL site to verify structural stability, flight characteristics, and apogee altitude.

l. *The following items should not be used in building the rocket:*
    a. *No flashbulbs. The recovery system must use commercially available*
    b. *Low-current electric matches.*
    c. *No forward canards n*

b. Mission Success (Complete) for payload
    i. Maintain continuous downlink of altitude/GPS data from ascent to retrieval
    ii. Full function of all onboard sensors and collection of data during entire flight profile.
    iii. Able to download all data to appropriate computers
    iv. Maintain structural integrity of all sensors and preserve ability to return to flight within 30 minutes.

c. Mission Success (Partial) for vehicle
    i. Achieve parabolic flight, but not to assigned altitude
    ii. Successful retrieval and maintain partial serviceability such that vehicle will return to flight after some repair
    iii. Controlled descent keeping electronics/scientific section intact.

d. Mission Success (Partial) for payload
    i. Transmit during >50% of flight
    ii. Download a minimum of 3 of 4 parameters and flight hardware reusable

e. Mission Failure (complete) for vehicle
    i. Failure to launch
    ii. Failure to reach 1,000 feet AGL altitude
    iii. Failure of main/lower stage parachutes to deploy
    iv. Structure too badly damaged to return to flight

f. Mission Failure (complete) for payload
    i. Failure to transmit data for more than 50% of the flight
    ii. Failure of batteries to prove power during entire flight
    iii. Failure of sensors to record data on more than 3 of 4 parameters

Fiberglass		#	10th

3. Weighting of items

Weighting factors

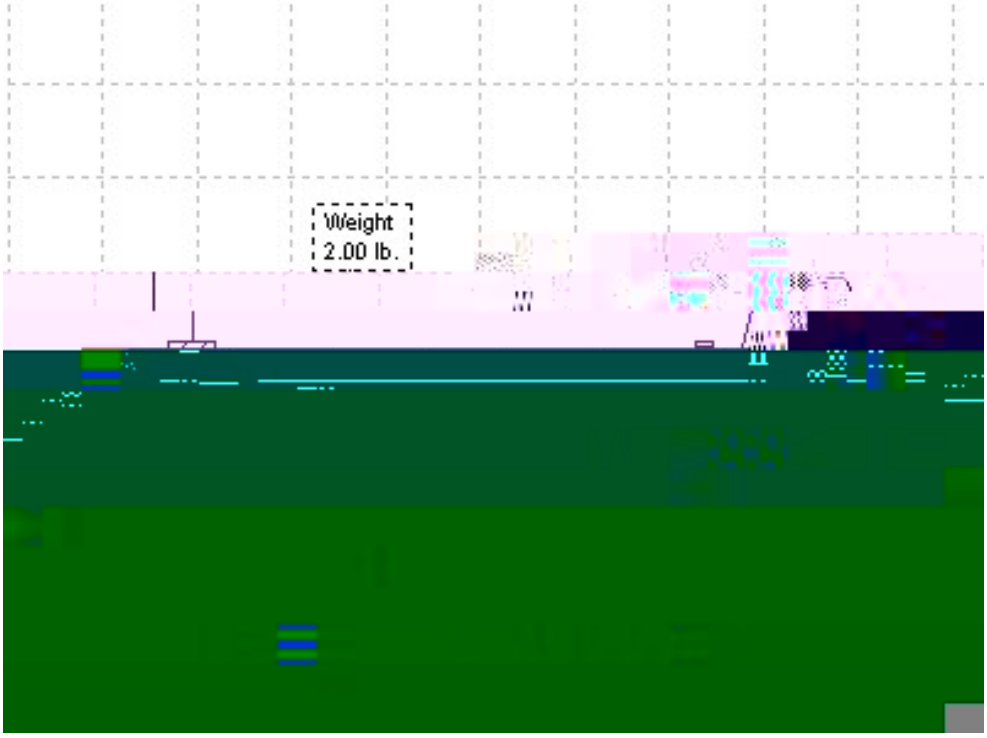
Material	1	Reason
Tensile Strength	1	Majority of flight profile will be in compression and will be augmented with stiffeners as needed
Modulus of Elasticty	2	Need a stiff material but not as critical
Cost	3	Very important due to budget constraints
Ease of machinability	2	Minimal equipment on hand to machine parts

4. Final values and selection

Final Values

Material	Tensile Strength (MPa)	Modulus of Elasticty (GPa)	Cost	Ease of Machinability	SUMS
(Kevlar/Twaral)	3	3	5	4	15
Nylon 6,6	1	1	5	6	13
Syalon 101	3	3	3	2	11

Vehicle Design Overview



Version 1 of Flight Vehicle

The overall length is 11.25 feet. The calculated cd-value is 0.75 and the lift-off weight is 23.31 pounds. The calculated Center of Gravity (CG) is 8.85 feet from the nose and the Center of Pressure (CP) is 9.25 feet from the nose. This gives the rocket a stability of 1.01 calibers.

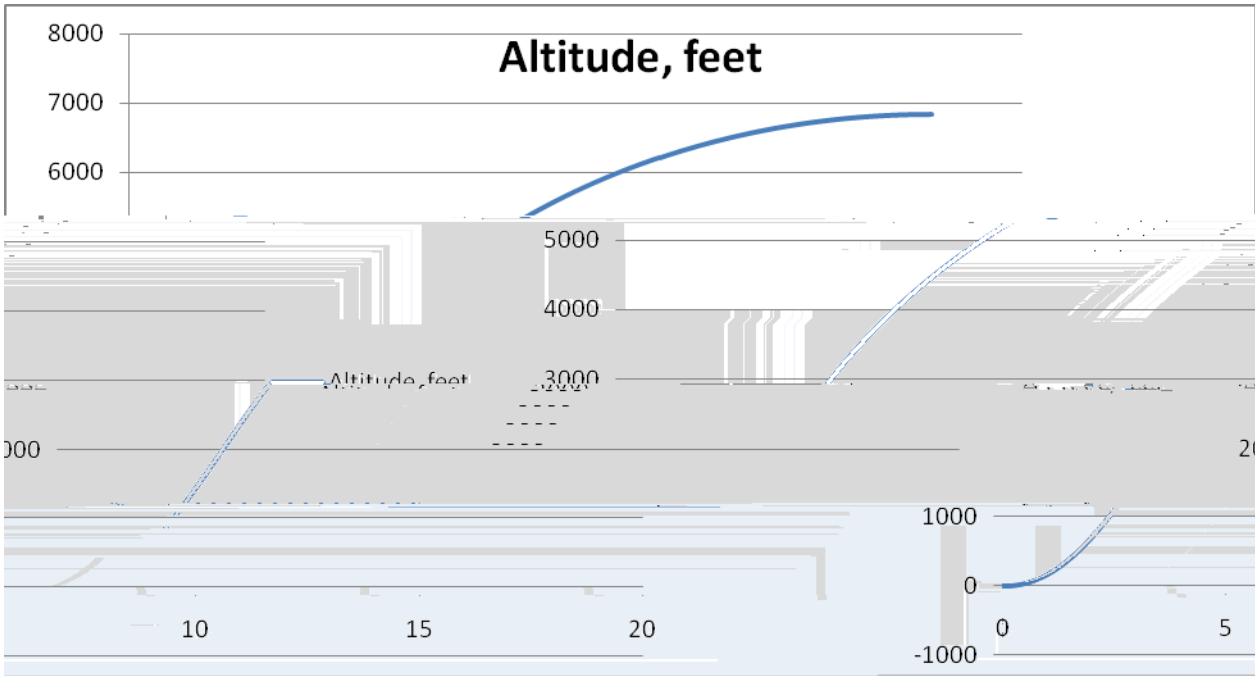
Recovery Subsystem

Initial sizing of the parachute for a single parachute is a diameter of 14.57 feet with a 12 panel design. We will use this as a basis to design two separate parachutes so that the aft section with the motor will descend more rapidly and the electronics section will descend at a rate not to exceed 10 feet/sec. The initial calculations given by SpaceCad v. 4 provided the initial parachute sizing and will be used for the two-parachute model. Testing will begin over December to determine the amount and type

of ejection charge. Use of either black powder or smokeless power is expected. All hazmat/safety procedures will be followed in regards to the explosive materials.

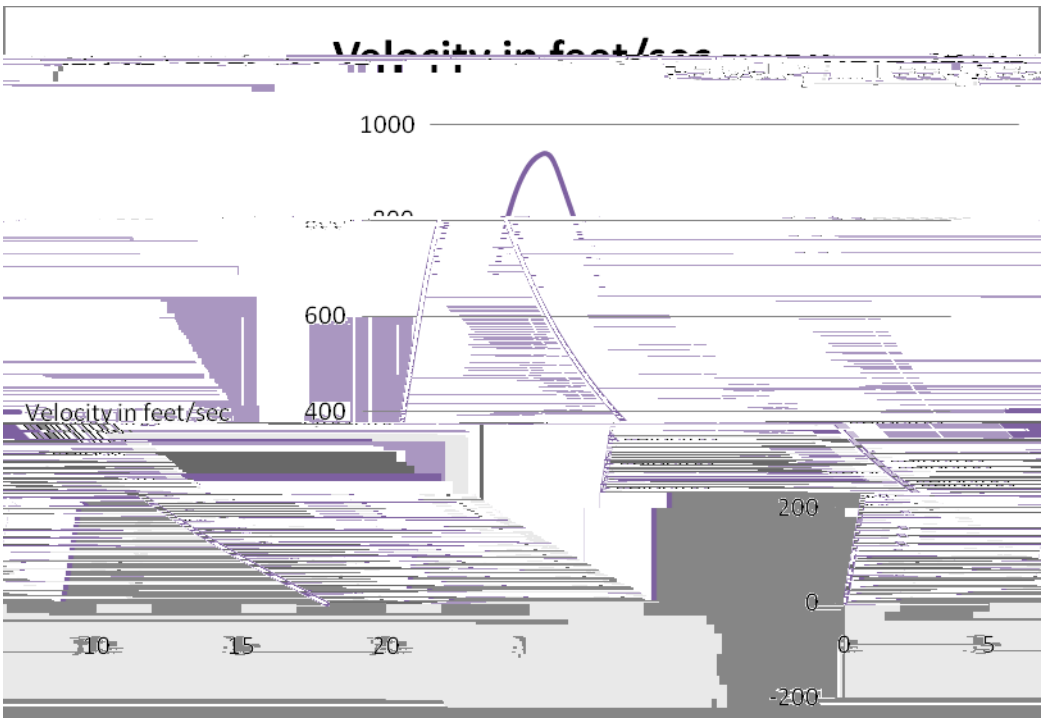
Mission Performance Predictions

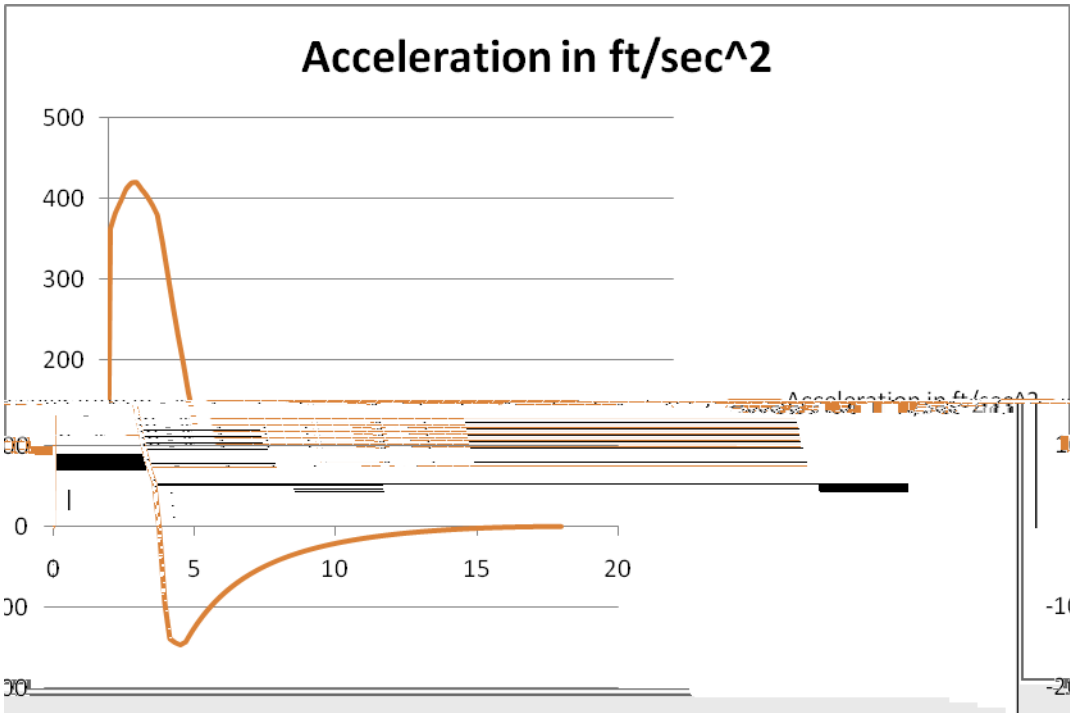
The following charts are the calculated values from SpaceCAD version 4.0. This model will give students the basis to start hand calculations as well as basic Theory of Column predictions on fuselage thickness, CP calculations from the Barrowman report, as well as physical calculations for the CG before/after the sections are built.

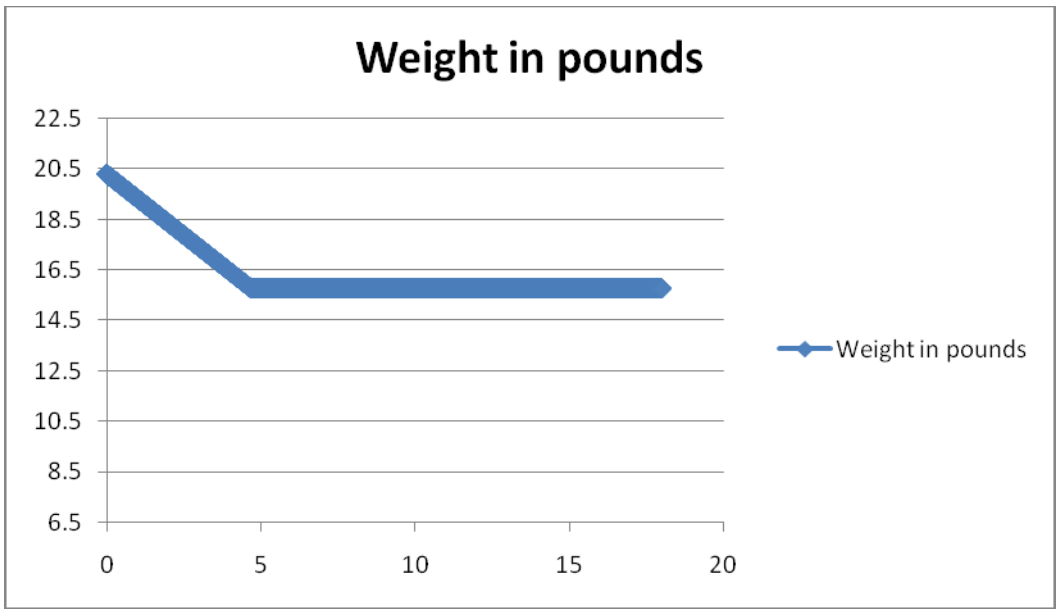


The altitude is in excess of the 5,280 feet target, but previous competitors have consistently come in under the target altitude so this team will allow for shortcomings in fuel/motor burn rate/pressure. This will be tested prior to launch to verify and any adjustments will be made in the mass of the rocket to ensure the target altitude is met. The section aft of the electronics package will be used as the variable section. This will be lengthened / shortened to adjust the CG/CP to provide stable flight.

The next graphs show the initial calculations for the velocity and acceleration based on the initial sizing of the rocket. These calculations were also performed in SpaceCAD v.4 and will be verified through testing and hand calculations. These are simply the first iteration of calculations. The initial calculations for motor mass were also provided so that the students would have a better final mass to calculate the needed area of the parachutes.


1000
600
400
200
0
Velocity in feet/sec
10
15
20
0
5
-200


Acceleration in ft/sec^2
500
400
300
200
0
0
5
10
15
20



Payload Integration

The payload will be situations such that the mass will as close to the bottom of the payload section as possible. This will assist in the CG determination and give the science team guidance on placement of sensors. The payload section will have suitable static ports drilled in the body to provide needed atmospheric access for both the barometric altimeters as well as the scientific sensors. Any solar panels will be placed in the skin of the section. All switches must be accessible from the outside to ease assembly and activation/deactivation of all power supplies and sensors.

Launch Operation Procedures

All launches will be held at NAR/TRA sanctioned sites. The launch rail will be provided and the overall length will be determined by the final length of the rocket. The minimum length is at least twice the length of the rocket, such that the overall length of the rail will be close to 25 feet in length. The assembly of the vehicle prior to launch will have the following sections:

a.

The motor will be assembled before arrival at launch site. The fuselage will be assembled before arrival at launch site. The only parts that will need to be assembled on site is the parachute to shock cord, shock cord to aft end, shock end to nose cone and avionics package. The science package will be enclosed in the fiberglass structure such that the switch will be accessible from the outside. Time to assemble will require a maximum of 30 minutes. The rail lugs will be compatible with the rail constructed. All safety precautions and guidelines will be followed in accordance with the NAR/TRA, BATFE, and NPFA regulations.

Safety and Environment (Vehicle)

The advisor safety officer for the team is Eldon Triggs and the student safety officer is Brandon Williams. The following list encompasses the possible failure modes of the vehicle.

1. Vehicle instability:

   Vehicle going off-nominal flight path. There is no destruct mechanism for the vehicle, therefore is no possible way to destroy the vehicle before impact. Stability must be maintained through proper design.

2. Parachute failure to deploy

   Spotters will maintain visual sighting of vehicle during ascent, apogee, and descent. Verification of vehicle location will be maintained at all times.

   If vehicle does not deploy parachutes, the safety officers will notify the participants immediately of parachute failure and give location of vehicle descent location.

   The ascent phase of the vehicle will be such that the vehicle moves away from any participants and all participants will be a sufficient distance to avoid injury.

3. Motor failure

   If the motor fails to ignite, on-site procedures will be followed regarding the Fail-to-fire. Personnel will approach only after a sufficient time has elapsed to verify that the motor is not “cooking off” and fire unexpectedly.

   A backup engine will be available for flight.

The following MSDS sheets and files are on hand to give students and faculty the necessary information regarding hazardous materials:

1. Ammonium Perchlorate
2. Kester solder
3. Bondo® Fiberglass resin
4. Owens-Corning Fiberglass fabric
5. Krylon® spray paint
6. Title 14, Part 101, Subpart C
7. NFPA 1127, Code for High Power Rocketry

The actual sheets are not included in this document in order to reduce overall length, but are available upon request.

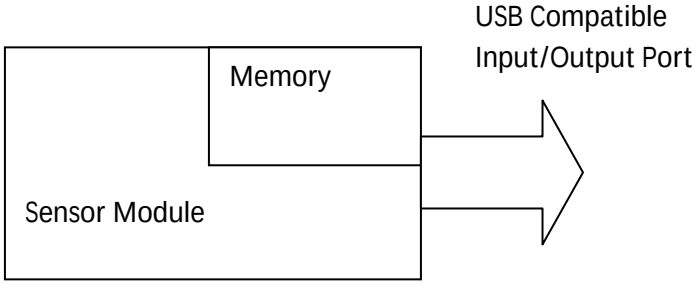
Payload Criteria

Payload

Item	Function
EL-USB-2-LCD	Humidity, Temperature and Dew Point Data Logger
EL-USB-CO	Carbon Monoxide Data Logger
MiniAlt/WD	dual logging event altimeter
standard serial RS-232 format adapter	PC connect data transfer kits for Altimeter
ARTS TX-900G	Altitude, GPS and Wind speed Telemetry transmitter
ARTS RX-900	Receiver for your Telemetry System
Standard Alkaline 9V battery	Altimeter Power supply

Carbon monoxide, Temperature, Humidity and Dew point sensors

The EL-USB-2-LCD and EL-USB-CO sensors have been chosen due to their low weight (0.3lbs each), easy use of usage, and programming. These sensors have inbuilt non volatile memory for storing the measured data and an internal lithium battery.



Altitude, GPS and Wind speed Transmitter and Receiver

Safety and Environment (Payload)

The safety officers will be the same mentioned in the vehicle section. The failure modes mention on page 7 will have the following mitigation plan:

1. Battery
    a. The potential problems with the lithium-polymer battery pack include fire and contact with skin.
    b. The battery will be charged in a Nomex sock with proper charging techniques in a safe area.
2. Motor
    a. The motor has the potential to catch fire and cause large fires.
    b. The motor(s) will be placed in approved containers and transported in accordance with Federal, State, and local laws. The motors will only be handles by NAR Level 2 certified personnel on site and during testing.

The items above are the most hazardous items when the vehicle is not in flight. The MSDS sheets and appropriate NFPA/NAR regulations are posted in a binder and are provided to students and faculty every time work is performed and are kept with the equipment as it is transported to/from launch sites. Equipment is kept on hand to clean up any spill or contamination to keep the environment from being harmed.

Budget

TU-LIP Rocket Construction Est. Budget

Item	Cost each
Fiberglass sheets	$50.00
Resin	$45.00
PVC core mandrel	

Tuskegee University

Cost Estimate for 1 year USLI Competition

Funding Agencies: Alabama Space Grant Consortium, Tuskegee University, External Sources

1. PI Salary /Fringe

ASGC 9/1/2008-7/30/2009	Tuskegee Cost Share 9/1/2008-7/30/2009	External Funding 9/1/2008-7/30/2009	Project Total 9/1/2008-7/30/2009
$1,312	$7,366	$992	
$240		$120	
$346		$298	
$200		$300	
$2,098		$1,710	
$2,870			
$300			
$7,366	**$7,366**	**$3,420**	**$14,732**

Timeline

The timeline is given on Page 8

Outreach summary

The students are planning a seminar with Booker T. Washington High School in Tuskegee and will work to encourage students to stay in STEM areas. There are at least one seminar planned for March.

Conclusion