Preliminary Design Review

YCP Student Launch

Vehicle Dimensions

- Overall length: 131 inches
 - Bottom body tube:

48 inches

Middle body tube:

38 inches

Top body tube:

22 inches

• Diameter: 6 inches

Fin Dimensions :

Chord Root: 36 cm Chord Tip: 25 cm

Height: 17.25 cm



Components	Ultimate Strength (KSI)	Weight (lb/in^3)	Max Temperature (F)	Poisson's Ratio		
Kevlar	522	0.052	850	0.36		
Fiberglass	300	0.055	2030	0.21		
Wood (Birch)	5.8	0.024	446	0.40		
Carbon Fiber	595	0.047	6332	0.10-0.20		
Phenolic	35	0.049	257	0.24		
Aluminum	45	0.098	1120	0.33		

Factors	Score Used in Decision Matrix
Safety	1-6; Highest Safety Material Gets a 1
Weight (Weighted By 2)	1-6; Lightest Weight Material Gets a 1
Cost (Weighted By 2)	1-6; Cheapest Material Gets a 1
Strength	1-6; Strongest Material Gets a 1
Poisson's Ratio	1-6; Lowest Poisson's Ratio Gets a 1
Fig 3A.2	2: Scoring Chart for Decision Matrix

Fig 3A.1: Material Properties

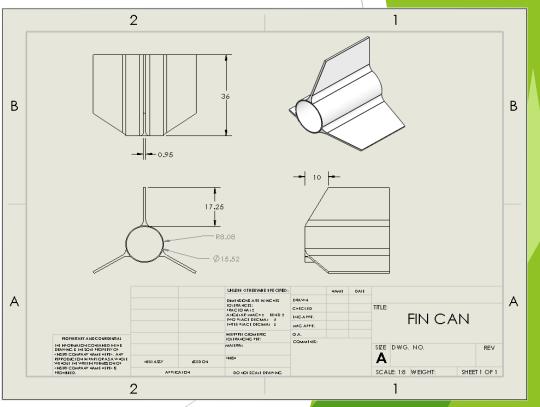
Components	Safety	Weight (X 2)	Cost (X 2)	Strength	Poisson	Total
Kevlar	3	8	10	2	5	28
Fiberglass	4	10	6	3	2	25
Wood(Birch)	6	2	2	6	6	22
Carbon Fiber	2	4	12	1	1	20
Phenolic	5	6	4	5	3	23
Aluminum	1	12	8	4	4	29
		Fig 3A	.3: Decision Matrix	[





Materials and Justifications

- Airframe: Fiberglasswrapped phenolic tubing vs. Carbon fiber tubing
- Fins: Ultem plastic vs. ABS plastic vs. PLA plastic
- Couplers: Phenolic tubing
- Nosecone: Fiberglass vs. PLA plastic
- Bulkheads: Wood
- Key Switches : SPDT Switch 11-3360 (Surplus Center)
- Battery Terminals : Keystone 1295 (Mouser Electronics)



Component Masses

	Weight (lb)
Nose Cone	2.50
Upper Body Tube	1.49
Payload	3.00
U-Bolts in Upper Body	0.18
Middle Body Tube	2.58
Coupler	0.65
Electronics Bay	1.50
Main parachute	1.02
U-Bolts in Middle Body	0.18
Shock Cord in Middle Body	0.30
Lower Body Tube	3.25
Motor Tube	0.60
Drogue Parachute	0.194
Shock Cord in Lower Body	0.30
U-Bolts in Lower Body	0.18
Motor	8.27
Fins	1.22
Total Weight	27.41
Simulation Mass	27.36

Major Calculations

All calculations verified via OpenRocket simulation and by hand calculations

Static Stability Margin

2.85 cal (Meets the design goal between with 2.5 < SM < 3.5)

Thrust to Weight Ratio 5.33 : 1

Center of Pressure 101.1 inches from nose

Center of Gravity 84.08 inches from nose

Rail Exit Velocity (from OpenRocket) 61.02 ft/s with a 12 ft long 1515 rail launch guide



Mission Preformance calculations

Maximum velocity at touchdown

one lbf = 32.174049 ft - lbs

total kenetic energy is 75ft-lbf therefore,

Ke=75*32.174049

Ke= 2413.1 $\frac{ft^2 - lbs}{s^2}$

to find the maximum velocity allowed at landing we use the equation

 $Ke = \frac{1}{2} * m * v^2$

where m is the mass of the rocket and v is the velocity it is traveling. The mass of the rocket is 27.412 lbs and kenetic energy was given. using this equation it can be rearranged to solve for v.

 $v = \sqrt{\frac{2 * \text{Ke}}{m}}$

m=27.412; v=sqrt((2*Ke)/m);

The maximum velocity the rocket can be traveling when it hits the ground is 13.269 ft or 9.047 mph

Kenetic energy by component

For the rocket when each component is separated from the rocket but attached by shock cord they will have the same velocity. Given the mass of each component, and the velocity, the kenetic energy of each component can be calculated.

For the nose cone and upper body tube section the the Kenetic energy is

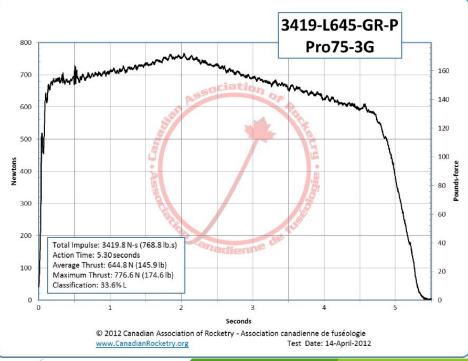
Mcu=2.5+4.67; Kcu=.5*Mcu*(v^2);

The Kenetic energy of the nose cone/ upper tube will be 631.169 $\frac{ft^2 - lbs}{2}$ or 19.617 ft - lbf.

Where K_{co} is the kenetic energy of the nose cone/upper body tube section and M_{co} is the mass of the nose cone/upper tube section.

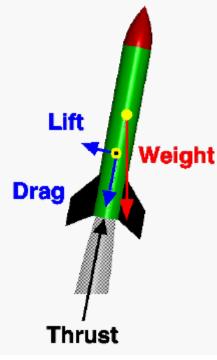
Preliminary Motor

- Motor Designation: CTI L645-P
- Max average thrust: 145.9 pounds
- Impulse of 3419 Newton-seconds over a burn time of 5.30 seconds
- Backup motor: L 1045-P
- Impulse of 3727 Newton-seconds



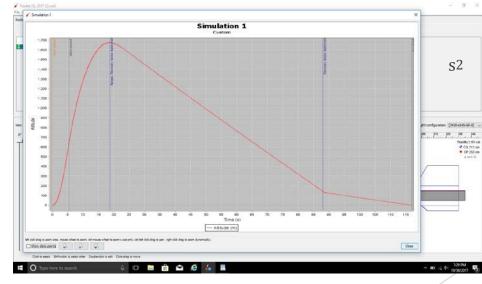
Justifications

- The main proposed motor should work due to the estimated 5% increase in weight of the rocket due to added supports, epoxy weight, and clay weight.
- Originally calculated point of apogee was 5504 feet but with the added weight it should be 5228 feet



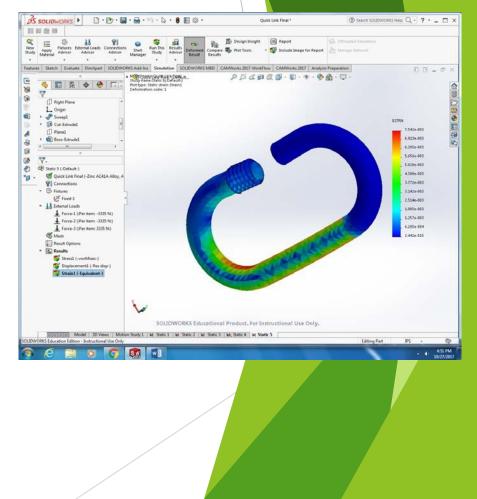
Recovery Subsystem

- 3.5g of black powder mass for both top and bottom sections respectively
- Force of Ejection: 755N
- Initial acceleration of front nose cone and payload section: 237.8
- Shock cord will be 4 times the length of the front body tube which is 38 inches long



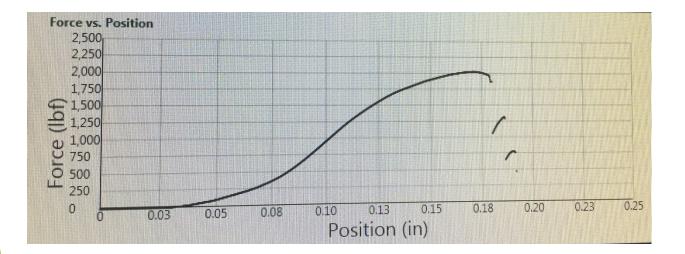
Recovery Subsystem: Components

- Quick links: Six, ¼ inch zinc coated
- Shock Cords: 1 inch Tubular Nylon
- U-bolts: Four, ³/₄ inch thick
- Drogue: 24 inches in diameter made by Fruity Chutes
- Main Parachute: 120 inches in diameter made by MediChutes



Justification

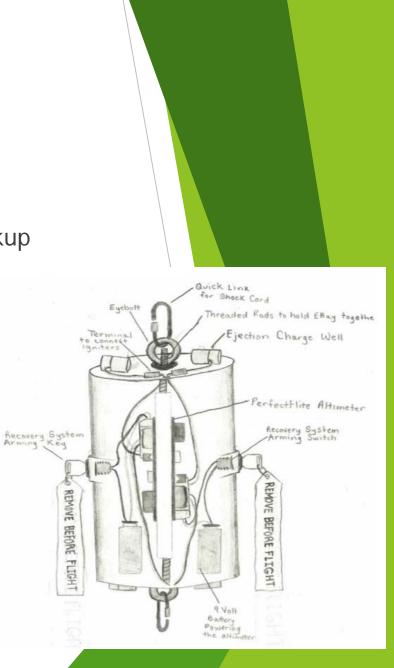
- Quick links: Able to withstand static forces up to 2030 pounds.
- Shock Cords: Yield of 4000 pounds and its less abrasive compared to Kevlar
- U-bolts: Yield of over 1000 pounds
- Drogue: Able to slow the rocket to terminal velocity
- Main Parachute: Calculations done to determine the size





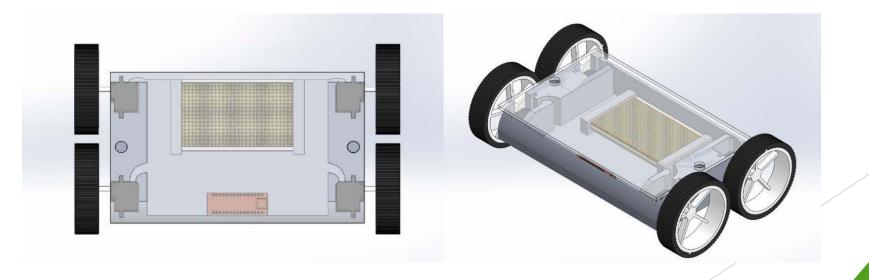
E-Bay: Recovery Electronics

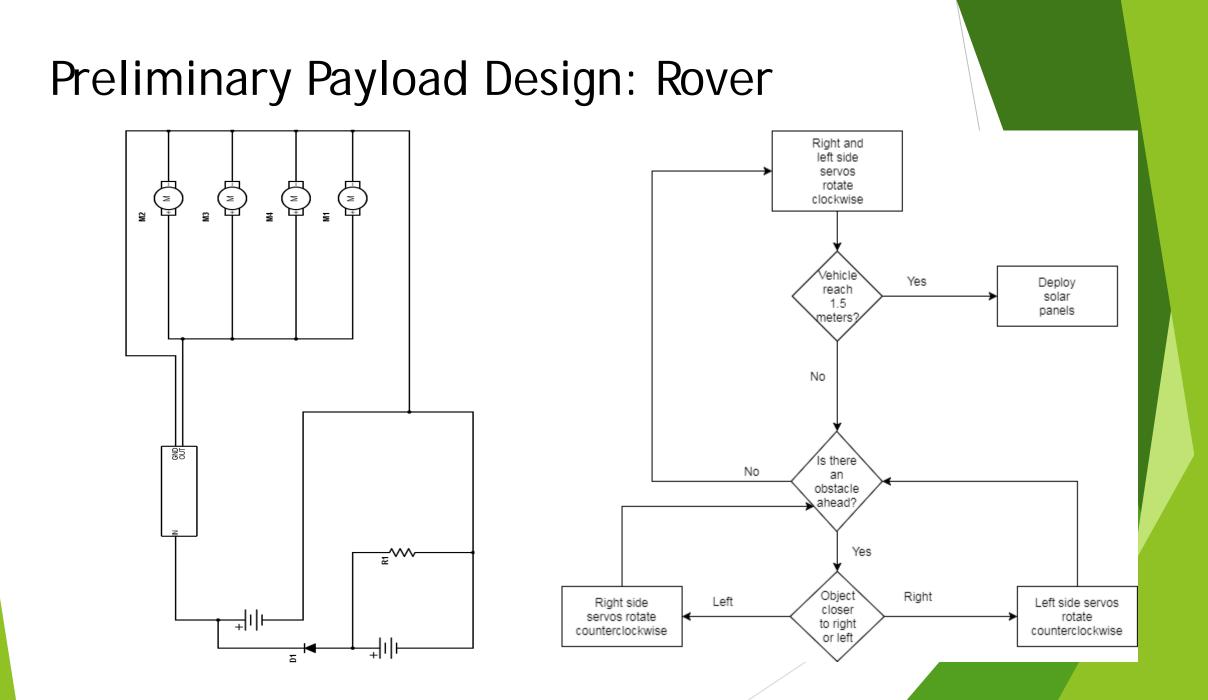
- Altimeters: PerfectFliteStratologger
- Redundancy plan: 2 Altimeters in the E-bay, one main and one as backup
- Pad stay time: 3 hours, we will be using 9V batteries



Preliminary Payload Design: Rover

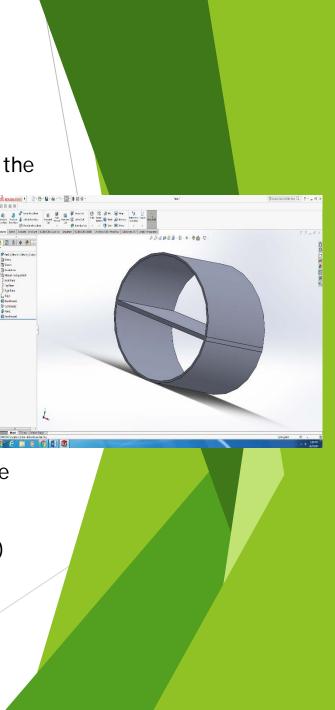
- Electrical parts: Arduino Nano, Ultrasonic sensor, Servos, Voltage regulator, Solar panels, GPS
- Each wheel has a servo motor
- Gaps implemented in the top plate to cool the electronics





Payload Integration

- The payload will be located in the 22 inch long front body tube section attached to the nose cone during flight
- After launch...
 - The nose cone and front body tube will become disconnected via the disconnection of an electromagnetic lock
 - The payload (rover) will be gently pushed out the front of the body tube by a series of solenoids located on the back bulkhead of the front body tube
 - The payload will then be able to perform its required functions
- The payload will fit within the front body tube and will be locked in place by its size
 - The board as seen below will be constructed to keep the payload from shifting around side to side during flight (may be reconfigured based on testing results)
 - Testing will take place with a mock payload to ensure that design functionality will work before CDR



Requirement Compliance Plan

6.1 - Verification Plan

	Verify	Plan	Each team must identify a "mentor." A mentor is	Demonstration	Our mentor is Dr. Ericson who is a	· · · · · · · · · · · · · · · · · · ·			The vehicle must be flows in its fully ballasted		The full-scale rocket will be from	tothered vehicle or any independent section to a	S		During test flights, teams will abide by the rules and	Demonstration We will listen to Bob Utley and
General Requirements Students on the team will do 100% of the project,	Demonstration	Each component of the rocket	defined as an adult who is included as a team member,		mechanical engineering professor	Pressure vessels on the vehicle will be approved by the	N/A	N/A	The vehicle must be flown in its fully ballasted configuration during the full-scale test flight. Fully	Demonstration	The full-scale rocket will be flown like it will be during the National	ground receiver. 3.10.1. Any rocket section, or payload	1		guidance of the local rocketry club's RiO. The	Brian Hastings, both Level 3 certified mentors who will be at
	Demonscracion	has been divided between the	who will be supporting the team (or multiple teams)		here at York College of PA.	RSO and will meet the following otteria:			comparation during the tun-scale test right, runy ballasted refers to the same amount of ballast that will		Byoff in Huntsville, AL	component, which lancis unter hered to the launch			allowance of partain vehicle configurations and/or payloads at the NASA Student Launch intertive does	centried mentors who will be at the NDRA launches when we are
including design, construction, written reports,			throughout the project year, and may or may not be			2.14.1. The minimum factor of safety (Burst or		1 1	be flown during the launch day flight. Additional ballast		HALL IN HURSWIRL ML	vehicle, will also carry an active electronic tracking			not give explicit or implicit authority for teams to fly	testing both our sub-scale and
presentations, and flight preparation with the		team members.	affiliated with the school, institution, or organization.			Ultimate pressure versus Max Expected Operating			be flown during the Isunch day flight. Additional ballast may not be added without a re-flight of the fullscale.			3.10.2. The electronic tracking device will be fully			those certain vehicle configurations and/or payloads a	full-scale rocket.
exception of assembling the motors and handling black			The mentor must maintain a current certification, and			Pressure) will be 4:1 with supporting design documentation included in all milestone reviews.			aunch vehicle.			functional during the official flight on launch day.			other club launches. Teams should communicate their	
powder or any variant of ejection charges, or preparing			be in good standing, through the National Association			2.14.2. Each pressure vessol will include a pressure		1 1				The recovery system electronics will not be adversely	Demonstration	No aim will connect between	intentions to the local club's President or Prefect and RSO before attending any NAR or TRA launch.	
and installing electric matches (to be done by the			of Rocketry (NAR) or Tripoli Rocketry Association (TRA)			relief valve that sees the full pressure of the valve that			After successfully completing the full-scale	Demonstration	The rocket will not be modified	affected by any other on-board electronic devices	Denoration	independent sections.	Teams will abide by all rules set forth by the F4A.	Communitations . Refer will be followed
team's mentor).			for the motor impulse of the launch vehicle and must			is capable of withstanding the maximum pressure and			demonstration flight, the launch vehicle or any of its		after full-scale testing.	during flight (from launch until landing).			Tearrs will adde by all thes sector in by the PARC	Send coater were will be followed.
The team will provide and maintain a project plan to	Demonstration	Project plan included in the POR.	have flown and successfully recovered (using			fow rate of the tank.			components will not be modified without the concurrence of the NASA Range Safety Officer (KSO).			3.11.1. The recovery system altimeters will be				
include, but not limited to the following items: project		,,	electronic, staged recovery) a minimum of 2 flights in			how rate of the tank.						physically located in a separate compartment within the vehicle from any other radio frequency				
milestones, budget and community support, checklists,			this or a higher impulse class, prior to PDR. The mentor							Demonstration	The rocket will be flown before	transmitting device and/or magnetic wave producing				
personnel assigned, educational engagement events,			is designated as the individual owner of the rocket for			2.14.3. Full pedigree of the tank will be described,			FRRs (March 6th, 2018). If the Student Launch office		March 6 th , 2018.	device.				
and risks and mitigations.			liability purposes and must travel with the team to			including the application for which the tank was		1 1	determines that a re-flight is necessary, then an extension to March 28th, 2018 will be granted. This			2.11.2. The recovery system electronics will be				
			launch week. One travel stipend will be provided per			designed, and the history of the tank, including the			extension to March 28th, 2038 will be granted. This extension is only usild for re-flights; not first-time			shielded from all onboard transmitting devices, to				
Foreign National (FN) team members must be	N/A	N/A	mentor regardless of the number of teams he or she			number of pressure cycles put on the tank, by whom,			detension is only void for re-regrits; not inst-time			avoid inadvertent excitation of the recovery system				
identified by the Preliminary Design Review (PDR) and			supports. The stipend will only be provided if the team			and when.			ingris.	a. (c.		electronics. 3.11.3. The recovery system electronics will be shielded from all oriboard devices which may				
may or may not have access to certain activities during			passes FRR and the team and mentor attends launch			The total impulse provided by a College and/or	Analysis	We plan on using an L-class	Any structural protuberance on the rocket will be located aft of the burnout center of gravity.	N/A	Agree	penerate manualic waves isuch as penerators, solenoid				
launch week due to security restrictions. In addition,			passes PRR and the team and mentor attends launch week in April.			University launch vehicle will not exceed 5,120		motor.				valves, and Tesla coils) to avaid inadvertent excitation				
FN's may be separated from their team during these						Newton-seconds (L-dass).			Vehicle Prohibitions	N/A	ngiaa	of the recovery system, 3.11.4. The recovery system				
activities.			The vehicle will deliver the payload to an apogee	Test	We have verified this using Open	The launch vehicle will have a minimum static stability	Demonstration	Our current calculations in both		N/A	Agree	electronics will be shielded from any other onboard	1			
The team must identify all team members attending	Demonstration	The final list will be presented in	altitude of 5,280 feet above ground level (AGL)		simulation.	margin of 2.0 at the point of rail exit. Rail exit is defined		the simulation and by hand have	The launch vehicle will not utilize forward firing	N/A	Agree	devices which may adversely affect the proper				
launch week activities by the Critical Design Review		the CDR.	The vehicle will carry one commercially available,	Test	We plan on testing the altimeters	at the point where the forward rail button loses	1.5mg	our rocket with a stability margin	motors.			operation of the recovery system electronics.				
(CDR), Team members will include:			barometric altimeter for recording the official altitude		by performing a sub scale launch.	contact with the rail.		of 2.35.	The launch vehicle will not utilize motors that expel	N/A	Agree	Each team will choose one design experiment option	Demonstration			
1.4.1. Students actively engaged in the project		I	used in determining the altitude award winner. Teams		1				titanium sponges (Sparky, Skkimark, Metallitorm, etc.)		· · · · · · · · · · · · · · · · · · ·	from the following list		aiready designed a rover for the		
throughout the entire year.		I	will receive the maximum number of altitude points		1	The launch vehicle will accelerate to a minimum	Demonstration			N/A	Agree			payload.		
1.4.2. One mentor (see requirement 1.14).			(5,280) if the official scoring altimeter reads a value of			velocity of 52 /ps at rail exit	Testing	the simulation and by hand have	The launch vehicle will not utilize a cluster of motors		Agree	Additional experiments (limit of 1) are allowed, and	N/A	N/A		
1.4.3. No more than two adult educators.			exactly 5280 feet AGL. The team will lose one point for				1	our rocket with a rail exit velocity	The set of the loss will not sense a prover of meters	1.41.5	1.0.11	may be flown, but they will not contribute to scoring.				
			every foot above or below the required altitude.					of 61.02 ft/s.	The second secon		In	If the team chooses to fly additional experiments, they	N/A	N/A		
The team will engage a minimum of 200 participants in	Demonstration		Each altimeter will be armed by a dedicated arming	Demonstration	The arming switches have been	All teams will successfully launch and recover a	Demonstration	We plan on launching a subscale	The Isunch vehicle will not utilize friction fitting for	Demonstration	The team will utilize a motor retainer for motor retaintion	still provide the appropriate documentation in all	1 m m			
educational, hands-on science, technology,		the York Country Day school	switch that is accessible from the exterior of the rocket		integrated in the E-bay design.	subscale model of their rocket prior to CDR. Subscales		rocket before the CDR so the	mutora		retainer for motor retaintion	design reports, so experiments may be reviewed for first satety.				
engineering, and mathematics (STEM) activities, as		where we will be holding	airframe when the rocket is in the launch configuration			are not required to be high power rockets.	1	altimeters can be tested.			14 Prints					
defined in the Educational Engagement Activity Report,		demonstrations and workshops.	on the launch pad.			2.18.1. The subscale model should resemble and			The launch vehicle will not exceed Mach 1 at any point		The rocket will not exceed Mach	All not applicable	NOA	N/A		
by FRR. An educational engagement activity report will				Demonstrate	Task alterative has been served 1.1	perform as similarly as possible to the full scale model,			during flight.	Simulation	1, and will reach a maximum	Teams will design a custom rover that will deploy from	Analysis	We already have design for the		
be completed and submitted within two weeks after			Each altimeter will have a dedicated power supply	vemonstration	Each altimeter has been provided	however, the full-scale will not be used as the subscale					speed of Mech 0.667	the internal structure of the launch vehicle.	-	rover completed.		
completion of an event. A sample of the educational					with its own power source.	model.			Vehicle ballast will not exceed 10% of the total weight	Demonstration	The vehicle ballost will not	At landing, the team will remotely activate a trigger to deather the second form the societ	Demonstration	A trigger will be activated after		
engagement activity report can be found on page 31 of			Each arming switch will be capable of being locked in		We will use Key Switches that are	2.18.2. The subscale model will carry an altimeter	1	1	of the rocket.		exceed 10% of the total weight of	deploy the rover from the rocket.	~~nstruction	landing to doploy the rover from the rocket.		
the handbook. To satisfy this requirement, all events			the ON position for launch (i.e. cannot be disarmed due	Inspection	capable of being in the "locked"	capable of reporting the model's apogee altitude.					the rocket.	<u></u>	1	Line rooker.		
must occur between project acceptance and the FRR			to flight forces).		position with the insertion of a											
cue date.					key.	[The launch vehicle will stage the deployment of its	Demonstration	This system will be set up through	After deployment, the rover will autonomously move	Demonstration	The mean will be reperantment via		
	-		The launch vehicle will be designed to be recoverable	Analysis	Most of the rocket components	All teams will successfully launch and recover their	Demonstration	The team plans to test launch the		Demonstration				and Arduino to move at least 5		
The team will develop and host a Web site for project	Demonstration		and reusable. Reusable is defined as being able to	1	are reusable right away.	fullscale rocket prior to PRI in its final fight configuration. The rocket frown at FER must be the		full-scale rocket during the	recovery devices, where a drogue parachute is	1	redundancy of the altimeters	at least 5 ft. (in any direction) from the launch vehicle.	wing			
documentation		created.	launch again on the same day without repairs or			configuration. The rocket flown at FRR must be the same rocket to be flown on launch day. The purpose of		MDRA February and March	deployed at apogee and a main parachute is deployed	1	within the electronics bey.		1	feet away from the rocket while		
		www.ycprocketry.weebly.com	modifications.		1			Launches which will occur before the FRR is due.	at a lower altitude. Tumble or streamer recovery from	1				also avoiding any obstacle		
						the full-scale demonstration flight is to demonstrate the launch vehicle's stability, structural integrity.		the PRK IS BUD,	apogee to main parachute deployment is also					in its' way by sensor recognition.		
			(Demonstration	Our design for the ported has *	the launch vehicle's stability, structural integrity,		the revisition.	permissible, provided that kinetic energy during					in its' way by sensor recognition to reach its target destination.		
Teams will post, and make available for download, the	Demonstration	The proposal was added when it	The launch vehicle nill have a maximum of four (4)	Demonstration		the launch vehicle's stability, structural integrity, recovery systems, and the team's ability to prepare the launch vehicle for flight. A successful flight is defined as		The Hex is due.						to reach its target destination.		
Teams will post, and make available for download, the required deliverables to the team web site by the due	Demonstration		The launch vehicle ntil have a maximum of four (4) independent sections. An independent section is	Demonstration	Our design for the rocket has 3 independent sections.	the launch vehicla's stability, structural integrity, recovery systems, and the team's ability to prepare the launch vehicle for flight. A successful flight is defined as a launch in which all hardware is functioning properly		The HICK IS BUD.	permissible, provided that kinetic energy during			Once the rover has reached its final destination, it will	Demonstruction	to reach its target destination. A set of solar panels will open up		
required deliverables to the team Web site by the due	Demonstration	was due and the FDR will also be	The launch vehicle nell have a maximum of four (4) independent sections. An independent section is defined as a section that is either bethered to the main	Demonstration		The luvech vehicle's stability, structural integrity, recovery systems, and the team's ability to prepare the faunch vence for flager, a successful flight is defined as a luvech in which all hardware is functioning properly (i.e. drogger, chira det apoger, main chure et a lower		The HKK IS due.	permissible, provided that kinetic energy during		We still perform ground ejection	Once the rover has reached its final destination, it will depicy a set of foldable solar cell panels.	Demonstration	to reach its target destination.		
required deliverables to the team Web site by the due dates specified in the project timeline.		was due and the FDR will also be added by due date.	The launch vehicle will have a maximum of four (4) independent sections. An independent section is defined as a section that is either tethered to the main vehicle or is recovered separately from the main	Demonstration		the launch whick's stability, structural integrity, moovery systems, and the team's ability to prepare the launch vence for fight. A successful fight or a defined as a launch is which all hardware is functioning properly (i.e. droppe chute at apoge, main chute at a lower attraction, incoming tracking devices, etc.). The		The HOL IS BUD.	permissible, provided that kinetic energy during drague-stage descent is reasonable, as deemed by the RSO.		We will perform ground ejection testing here at York College to		Demonstration	to reach its target destination. A set of solar panels will open up		
required deliverables to the team Web site by the due dates specified in the project timeline.		was due and the FDR will also be added by due date. All files will be converted to PDF	The learnch vehicle will have a maximum of four (4) independent sections. An independent section is defined as a section that is either tethered to the main vehicls or is recovered separately from the main vehicle using its own persolute.	Demonstration	independent sections.	the launch vehicle's stability, structural integrity, incovery systems, and the team's ability to separe the launch vehicle for flight. A successful flight is defined as a launch in which all handware is functioning properly (i.e. diogue chief as explore, mini chief at a lower altitude, functioning tracking devices, etc.). This following or tracking devices, etc.).		The HOL 6 due.	permissible, provided that kinetic energy during drogue-stage descent is reasonable, as deemed by the RSO. Each team must perform a successful ground ejection	Testing		depicy a set of foldable solar cell panels.		to reach its target destination. A set of solar panels will open up after the rover reaches its final destination.		
required deliverables to the team Web site by the due dates specified in the project timeline.		was due and the FDR will also be added by due date. All files will be converted to PDF format.	The launch vehicle will have a maximum of four (4) independent sections. An independent section is defined as a section that is either tethered to the main vehicle or is recovered separately from the main	Demonstration Test		the launch vehicle's stability, structural integrity, rescover, synteme, and the team's ability to prepare the launch venicle for figure. A successful fight is defined as a lounch in which all hardware is feastcoining properly (i.e. drogan chute et apoger, main chute et a louen attrature, finctioning tracking descere, etc.). The following orientia must be met during the full scale demonstration flight:		the Hol K dup.	permissible, provided that kinetic energy during drogue-stage discent is reasonable, as deemed by the RSO. Each team must perform a successful ground ejection test for both the drogue and main parachetes. This	Testing	testing here at York College to ensure that the ejection charge	depicy a set of foldable solar cell panels. All not applicable	N/A	to reach its target destination. A set of solar panels will open up after the rover reaches its final destination. N/4		
required delinerables to the team Web site by the due dates specified in the project timeline. All deliverables must be in PDF format. In every report, teams will provide a table of contents.	Demonstration	was due and the FDR will also be added by due date. All files will be converted to PDF	The issunch whiche will have a maximum of four (4) independent section. An independent section is defined as a section that is other technered to the man which or in recoveries expanding from the main which curring its own prochester. The issunds which will be limited to a single stage.	Test	Independent sections. One meter, a "CT11-645" will be used.	the lawsh web dis stability, thrustnal integrity, recovery system, and the sensi habits to perpare the lawsh whether for fight a successful fight a defined as a lawsh in which is lawshame is functioning properly (as disput churke et apoger, main churk et a lower attrices, functioning tracking devices, etc.). The following criteria must be med auroptic fund acad demonstration fight: 2.13.1. The which card networky system will have		the Hol K dup.	permissible, provided that kinetic energy during drogae-stage descent is reasonable, as deemed by the 880. Each beam must perform a seccessful ground ejection- test for both the drogae and main perschetes. This must be done prior to the initial subscale and full-scale must be done prior to the initial subscale and full-scale	Testing	testing here at York College to	depicy a set of foldable solar cell panels. All not applicable Each team xill use a launch and safety checklist. The	N/A	to reach its target destination. A set of solar panels will open up after the rover reaches its final destination. N/4		
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