Recovery Section

Design Review

Sims group

Sims: Goals

Analyze driving factors

Proliferate/communicate driving factors throughout subteams/RE’s (specifications)

Formalize rocket capabilities/tolerances

Misc specific simulations/calculations

Analyze and proliferate key driving factors and their implications throughout the team to increase reliability, capability and understanding of the rocket in preparation for space shot.

Sims: now and future

Factor	Source
Max Drogue force	Sims
Max Main force	Sims
Max Compressive loads	Sims
Max integrated heat load	Sims
Impact	Sims
Separation force (shear pins)	Piston design/testing
Max vibration load	unknown
Separation shock	unknown

Accuracy of Mass Budget is ESSENTIAL

- Deployment force/velocity range driven by changes in mass

Communicating/officializing design changes

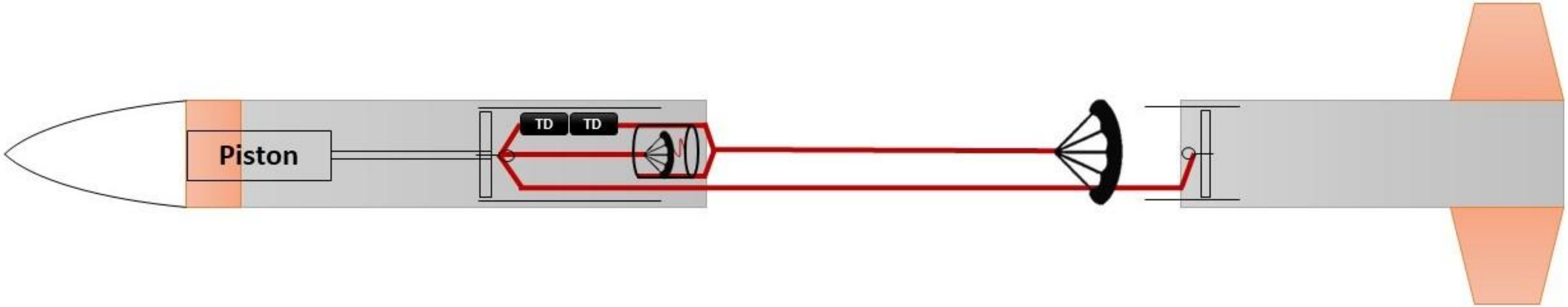
Collaboration and review of sims

Overview

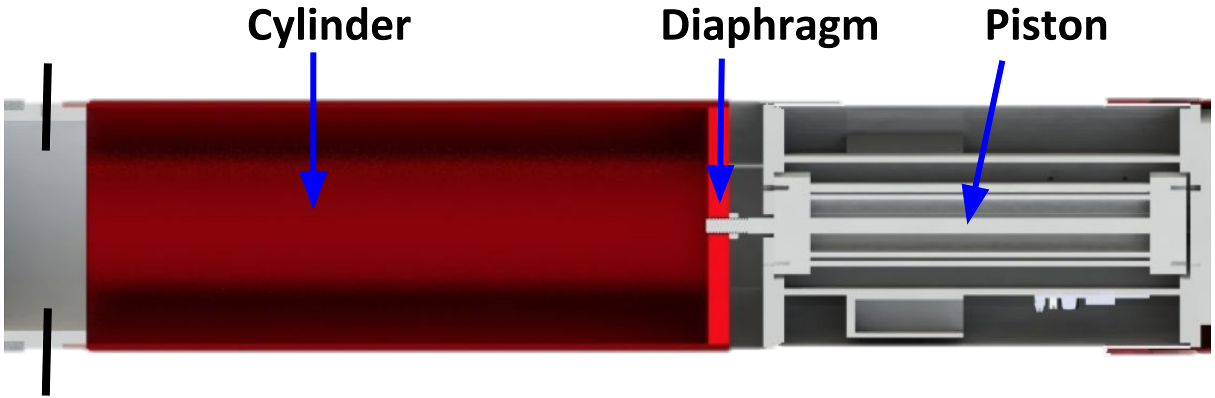
Design Overview

Single Separation Dual Deploy

1. Piston separates rocket
2. Motor section inertia deploys drogue
3. Descend until 2000 ft
4. TD releases main
5. Drogue extracts main
6. Main inflates
7. Hit ground at 30-40 ft/s



Piston
TD
TD



Cylinder
Diaphragm
Piston

Interfaces

Driving factors:

- Drogue and Main deployment (recovery specific calculations)
- Separation shock (hard to qualify)
- Compressive loads (sims)

Key components

- Payload bulkhead design
- Mystery box (volume)

Design Overview: Changes from Hermes I

- Heavier rocket:
  - higher deployment forces
  - higher impact velocity
- Greater emphasis on recovering the rocket safely
  - reusability for next year

Inherited Risks

- webbing twisting
- untested parts
- piston twisting
- disorganized integration causing delays and failures at launch

Risks and Mitigations for flight

ID	Risk Statement	Impact	Likelihood	Response	Responsible Party
1	Drogue Twisting	High	Medium	Research and design; white paper	Maggie Z
2	Rocket Separation	High	Medium	Piston Testing	Jiaheng
3	Drogue Inflation	High	High	Drogue Bag	Claire B
4	Main Deployment	Medium	Medium	Tow Testing, large design margins	Claire W
5	Fail qual tests	High	High	Who has time to fix problems?	Jakob C
6	Not ready for CRIMP	High	High	What do we slip?	Jakob C

Risk Matrix

Risk	20%				5, 6	3
	10%					
	5%			4		1, 2
	1%					
	0.1%					
		1	2	3	4	5
Subsystem		Impact				

Key			
Acceptable risk	RE / TL Decision	Exec Decision	Unacceptable

Design Overview: This year's goals

Prepare for Spaceshot

Recover Hermes in reflyable condition

Retrieve data

→

Designing for future iterations of booster (higher mass and thrust in sims)

Improving reliability through testing

Develop testing procedures that are useful in the future

Design Overview -> Functions

Systems engineering approach:

- Simulations and Calculations (inform specifications)
- Testing (verify specifications)
- Integration (validate)

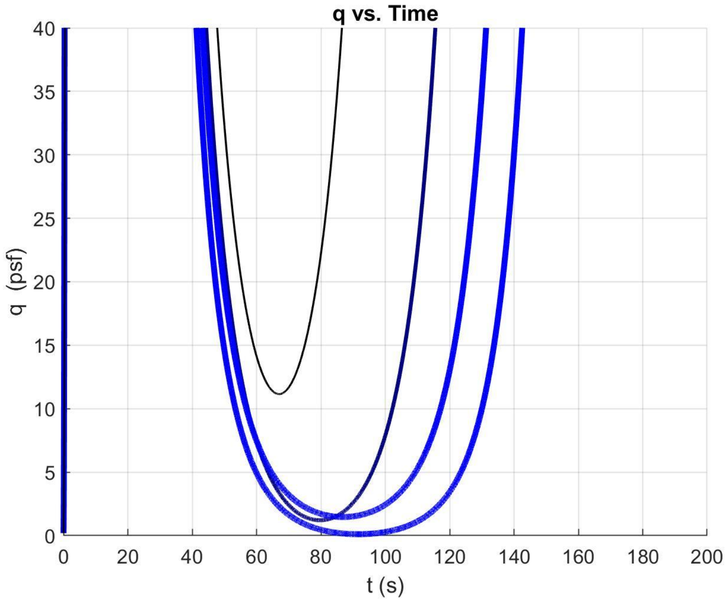
Physical Parts: Design and select/build components

Functions

SIMULATIONS AND CALCULATIONS

Simulations subteam outputs

Recovery specific parameters and calculations



Descent and Impact Velocities

	Drogue	Main	
Nominal Velocity	105.8	29.1	ft/s
Maximum Velocity	115.9	30.9	ft/s

We hit the ground fast
However, Hermes II is much stronger than a typical rocket

Deployment Forces

	Drogue	Main
Nominal Deployment Force	17	1881 lb
Max Deployment Force	181	2256 lb

TESTING

Subsystem	Sims/Calculations/Driving Factors	Testing
Parachutes/lines	Descent rates	Tow test to evaluate deployment forces
Piston Cup assembly	Piston force Deployment forces	Piston testing to qualify force and amount of black powder
Tender Descender/AARD	Deployment forces	Testing next week
Swivels	Deployment forces	Instron test to qualify deformation

System tests: Vac/Vibe, Ground test, Integration

Piston Testing

- What is the piston test?
- Developed piston procedures
- Plan
  - Qualify separation force + shear pin strength
- Next Steps
  - Test with pressure sensitive film
  - Test nylon firebolts
  - Test with drogue
  - Select shear pins

11/2/18 0.1g black powder, 2 shear pins

Piston Qualification Test

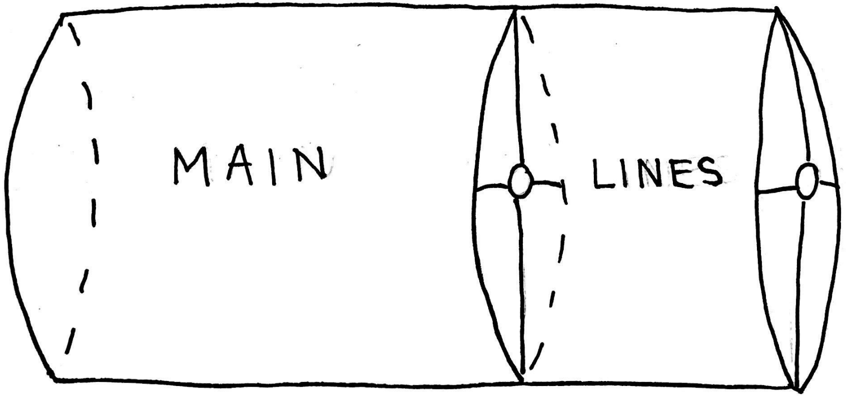
Qualifies flight hardware for recovery

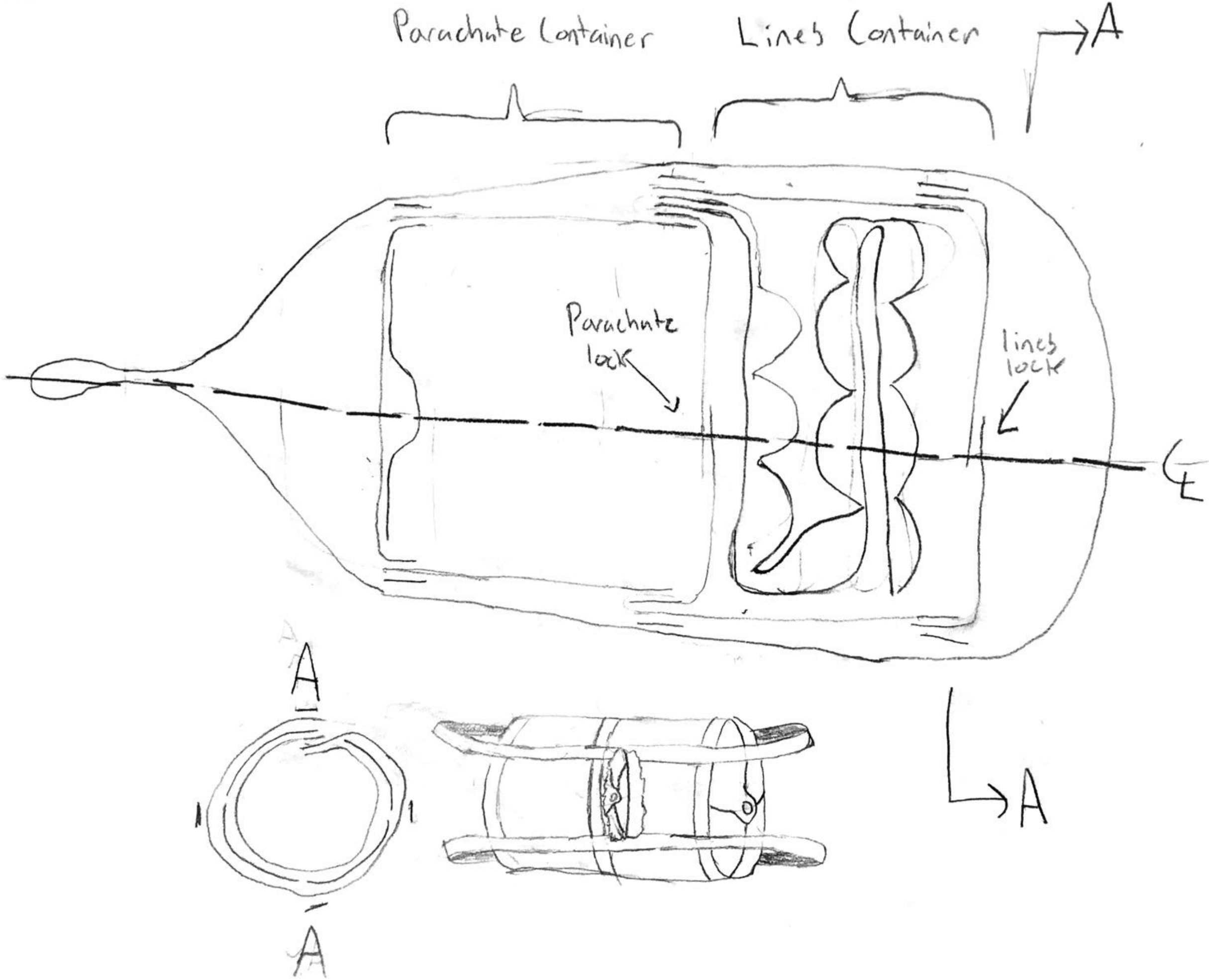
- Verify that the mission package structures can withstand separation load
- Verify that the drogue deploys
- Verify that the main is retained

- Faster, easier, and more controlled than a ground test
- Schedule TBD because timeline for mystery box, drogue bag, mission package tube, and payload coupler are not yet firm

Deployment Bags

- Designing and constructing new deployment bag for the main
- Lines will be stowed and slid into an extension of the bag



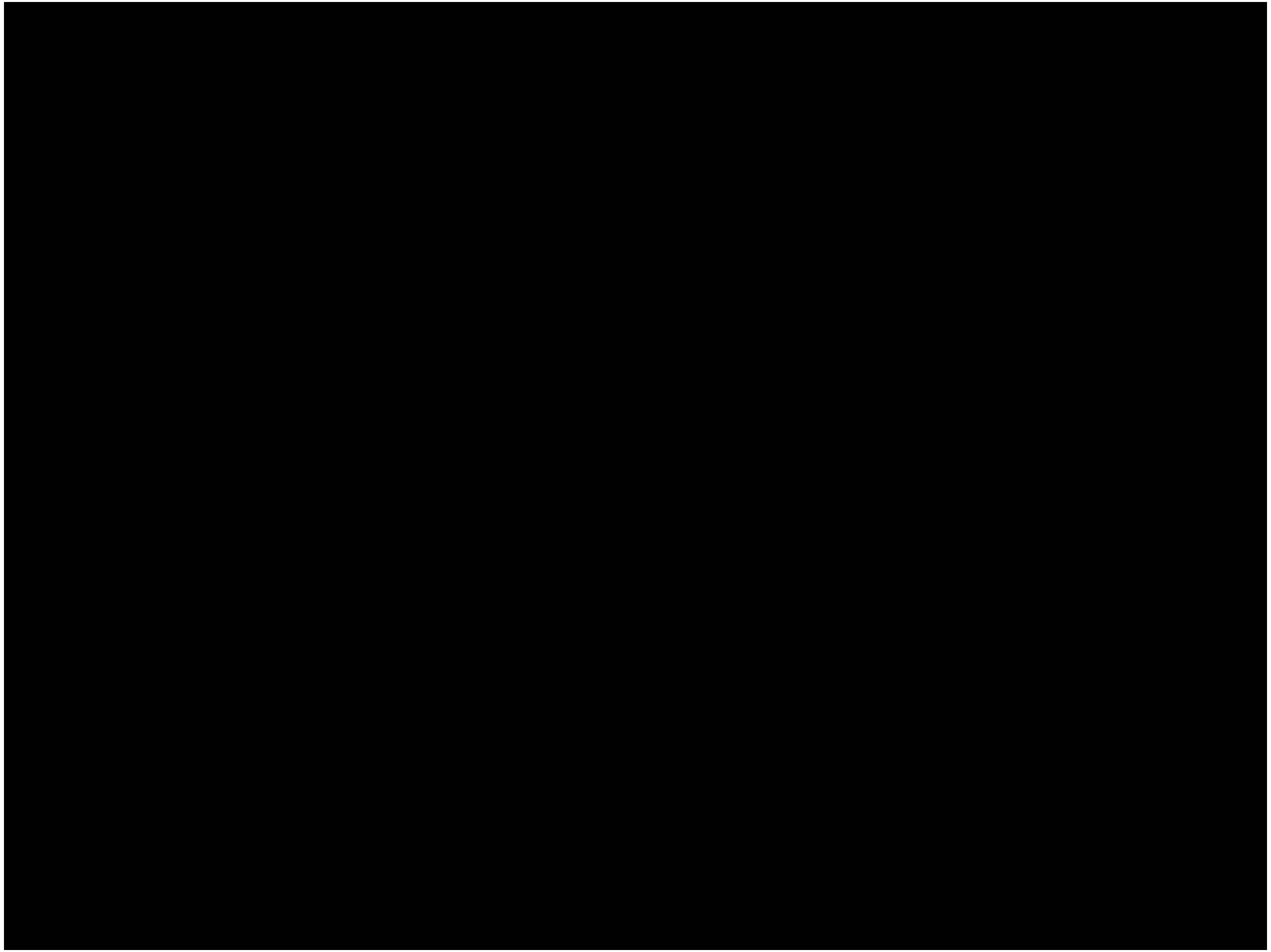

Parachute Container
Lines Container
A
Parachute lock
lines lock
A
A
A


MIT Rocket Team:

Tow Testing

- Purpose: test main parachute extraction
  - **Deployment force calculations assume orderly, lines first deployment i.e. function bags**
- Observing parachute and bag for tears and burns and smoothness of extraction
- Results: Tested extraction at ~30 mph
- Parachute and line extraction was smooth
- No damage to parachute or bag
- New bag closure system worked well
- Another tow test will be performed with the new parachute bag
  - Verify flight main bag


DUNKIN' DONUTS



Future Testing

Vac/Vibe testing

- Ensure piston and avionics can withstand vacuum and vibration loads

Ground Test

- Scheduled for CRIMP week
- Tests the recovery system and rocket separation

INTEGRATION

The challenge is that recovery is running a faster schedule than the parts are coming out

Another issue is losing parts

Goal is CRIMP on Dec 1

Integrate and test parts as they come out

Test - CRIMP - test - CRIMP

- Tests may happen after CRIMP

Integration Procedure

See very detailed integration wiki for detailed procedure

- Sub-assemblies tests produce sub-assembly procedures
- These get pushed to the master integration as they are completed
- Integration RE coordinates with those responsible for the sub-assemblies
- Update integration procedures with each integration and test

PHYSICAL PARTS

- Parachutes/lines
- Piston Cup assembly
- Tender Descender/AARD
- Swivels

WBS NUMBER	TASK TITLE	TASK OWNER	PCT OF TASK COMPLETE
3	**Hard Goods**		
3.1	Payload Bulkhead	Herbie T	0%
3.2	AV Tower	Max K	0%
3.4	Mysterybox		0%
3.3	Mission Package Tube Machining		0%
3.7	Firebolts	Prem C	100%
3.8	Piston Testing	Jiaheng Z	50%
3.9	Shear Pins	Jiaheng Z	0%
3.1	Piston Qualification Tests	Jiaheng Z	0%

Build									Testing			Integration		
WEEK -4			WEEK -3			WEEK -2			WEEK -1			WEEK 0		
27-2			3-9			10-16			17-23			24-30		
S	Su	MF	S	Su	MF	S	Su	MF	S	Su	MF	S	Su	MF

Piston qualification test time?

Bill of Materials

Part	#	Mass (lbs)	Tolerance	Total
Piston	1	1.635	0	1.64
Cup	1	2.015	0.5	2.02
Diaphragm	1	0.74	0.1	0.74
3/8-16 Eye Nut	1	0.15	0	0.15
1/8 NPT Plug with 1/4-20 hole	2	0.02	0	0.04
1/8 NPT T-Fitting	1	0.065	0	0.07
FireBolt	4	0.011	0.002	0.04
Tender Descender	2	0.07	0	0.14
Drogue Parachute + Deployment Bag	1	0.52	0.2	0.52
Main Parachute + Deployment Bag	1	2.905	0.2	2.91
1000lb Quicklinks	7	0.12	0	0.84
880lb Quicklinks	0	0.07	0	0.00
220lb Quicklinks	0	0.02	0	0.00
1500lb Swivels	4	0.05	0	0.20
300lb Swivels	0	0.01	0.02	0.00
Main riser	7.16	0.0264	0.0264	0.19
Drogue riser	6.34	0.008911	0.00158	0.06
MP to Booster	38.9	0.008911	0.00257	0.35

Manufacturing Plan

- The cup fits in the new tubes → Cup and diaphragm do not need to be remade
- Manufacture Lines
  - Deployment forces are up this year
  - Drogue lines are still okay. Main risers and links need to be much stronger
- Deployment bags are being designed and sewn
  - Tow test was successful
- More firebolts for piston
  - Nylon bolts have been machined

Main Hardware Changes from Hermes I

Main Quicklinks, Swivels, and Eye have to be stronger to withstand main deployment

Soft Good Changes from Hermes I

Main Riser: Single 4000 lb tubular nylon member no longer strong enough to withstand deployment forces. Options:

- Two 4000 lb tubular nylon members in parallel
  - Have the material
  - New manufacturing methods -- join two risers together
  - Difficult to pack and high volume
- Single 12000 lb Spectra braided line
  - 1/8 volume of nylon equivalent
  - New manufacturing methods -- finger trapping is hard because spectra is slippery
  - Melts at 230 F, however Fruity Chutes uses spectra in its highest end ellipticals

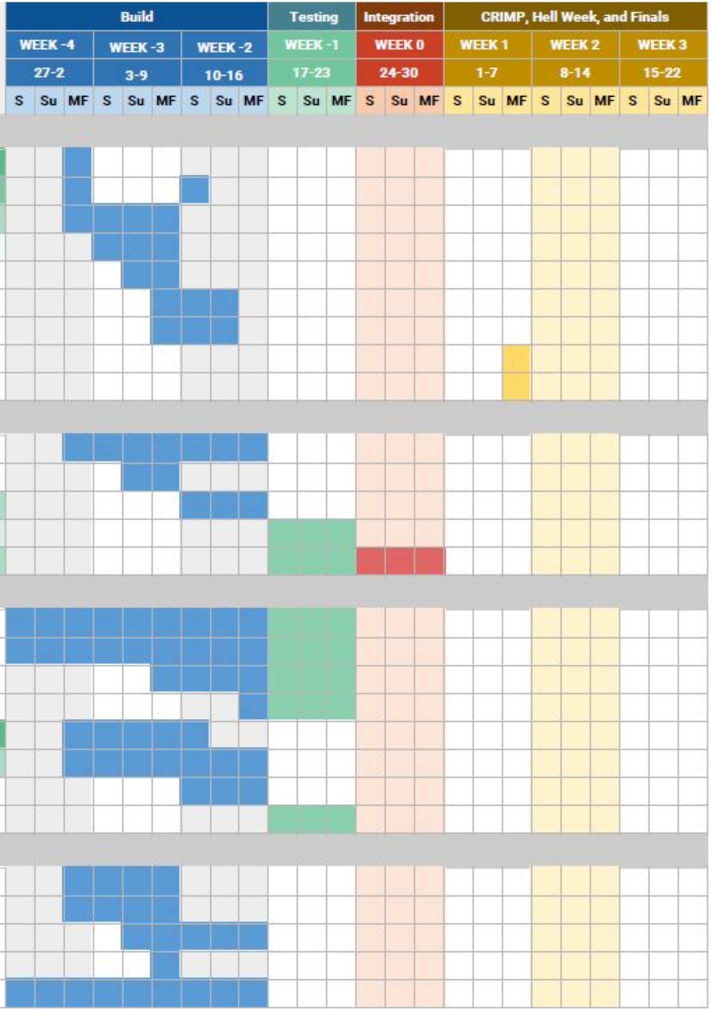
Spectra will be ordered soon. Plan to descope to Nylon if necessary.

Instron Testing

- Tensile testing will confirm that hardware can withstand deployment forces
- Swivel connected to main parachute deformed on Hermes
- Hardware:
  - Swivels
  - Quicklinks
  - Webbing
- Happening in the next two weeks

Schedule to Completion

WBS NUMBER	TASK TITLE	TASK OWNER	PCT OF TASK COMPLETE
1	**Sims and Specifications**		
1.1.1	Specification Sims	Shannon C	100%
1.1.2	Specification Sims Results	Shannon C	80%
1.2	Written Specifications	Shannon C	50%
1.3	Cassandra	Shannon C	10%
1.4	Cherry-Limeaid Thrust Curve	Ethan S	0%
1.5.1	Motor Updated Sims	Shannon C	0%
1.5.2	Motor Updated Sims Results	Shannon C	0%
1.6.1	Flight Sims	Shannon C	0%
1.6.2	Flight Sims Results	Shannon C	0%
2	**Procedures**		
2.1	AV Bay Integration Procedure	Max K	0%
2.2	TD integration procedure	Ellen L	0%
2.3	Piston integration procedure	Jiaheng Z	50%
2.4	Parachute Packing Procedure	Maggie Z	25%
2.5	Overall Integration Procedure	Maggie Z	50%
3	**Hard Goods**		
3.1	Payload Bulkhead	Herbie T	0%
3.2	AV Tower	Max K	0%
3.4	Mysterybox		0%
3.3	Mission Package Tube Machining		0%
3.7	Firebolts	Prem C	100%
3.8	Piston Testing	Jiaheng Z	50%
3.9	Shear Pins	Jiaheng Z	0%
3.1	Piston Qualification Tests	Jiaheng Z	0%
4	**Recovery Conections**		
4.1	Swivels	Prem C	0%
4.2	Piston Eye	Maggie Z	0%
4.3	TD Loops	Claire W	0%
4.4	TD Tests	Ellen, Claire W	0%
4.5	Motor Recovery Connection		0%



WBS NUMBER	TASK TITLE	TASK OWNER	PCT OF TASK COMPLETE
5	**Soft Goods**		
5.1.1	Protoype Bags	Jakob, Claire B	10%
5.2.1	Lines Research and Testing	Claire W	25%
5.2.2	Lines Qualification	Claire W	0%
5.2.3	Manufacuture Flight Lines	Claire W	0%
5.3.1	Tow Testing	Claire W	0%
5.1.2	Flight Bags	Claire B	0%
3.3.2	Tow Qualification Tests	Claire W	0%
6	**Flight Qualification Testing**		
6.1	Vac/Vibe		0%
6.2	AV Drop		0%
6.3	CRIMP	Maggie Z	0%
6.4	Ground	Ellen L	0%
7	**Post CRIMP**		
7.1	Post Flight Inspection Procedure	Maggie Z	0%
7.2	Mass-Cost-Time Trade Analysis	Jakob C	0%
7.3	Plan IAP	Jakob C	0%
8	**Events**		
8.1	Recovery Meetings	Jakob C	30%
8.2	Sims Meetings	Shannon C	0%
8.4	Design Review	Shannon C	0%
8.3	Burwick	N/A	0%
8.5	Thanksgiving	N/A	0%
8.6	Water Rockets	N/A	0%
8.7	Hell Week	N/A	0%
8.8	Finals	N/A	0%

Build			Testing	Integration	CRIMP, Hell Week, and Finals		
WEEK -4	WEEK -3	WEEK -2	WEEK -1	WEEK 0	WEEK 1	WEEK 2	WEEK 3
27-2	3-9	10-16	17-23	24-30	1-7	8-14	15-22
S Su MF	S Su MF	S Su MF	S Su MF	S Su MF	S Su MF	S Su MF	S Su MF

Yay rockets!