Payload Separation System

Progress Report

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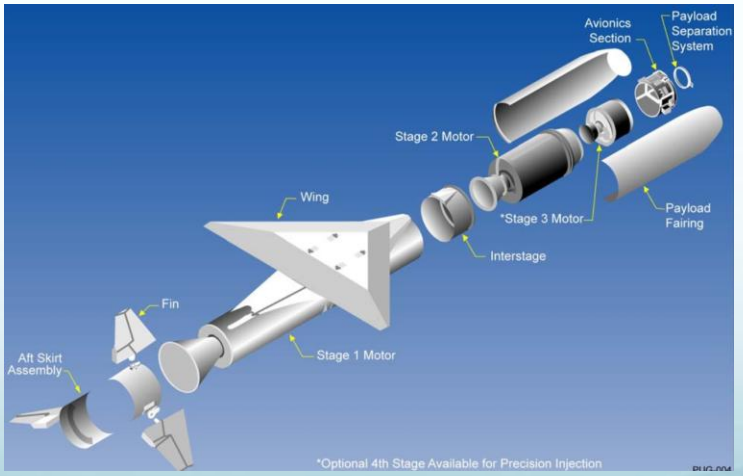
Overview

- Review
- Objectives
- Design Manufacturing
- Final Design and Components
- Engineering Analysis Alterations
  - Solenoids
  - Shear on Keys
  - Kick off Springs/Magnets
- PSS Testing
- Costs
- Gantt Chart
  - Spring 2014
- Conclusion
- References

Review

- Problem Statement:
  - Design, analyze, build, and test a less expensive payload separation system that delivers payloads into orbit with minimal shock to the payload.
- Client:
  - Orbital Sciences Corporation
    - Mary Rogers: Electronic Packaging and Actuators Manager
    - Stakeholders: Companies/Agencies whom contract with Orbital Sciences



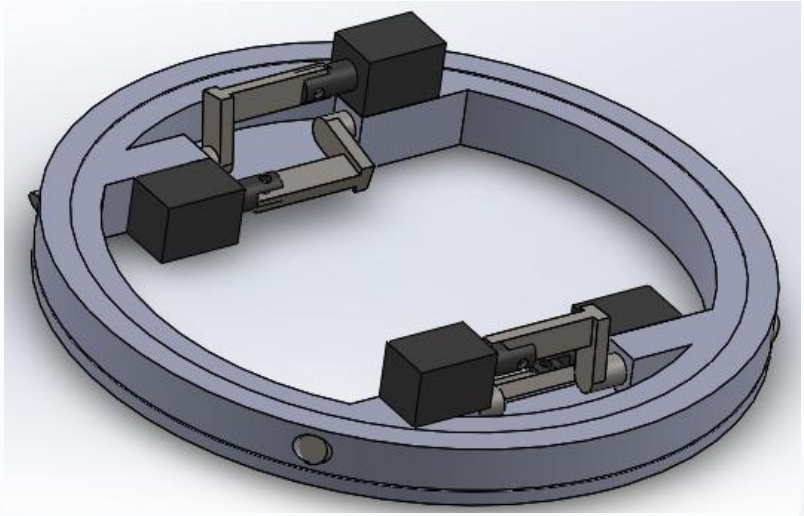
http://www.orbital.com

Design Manufacturing

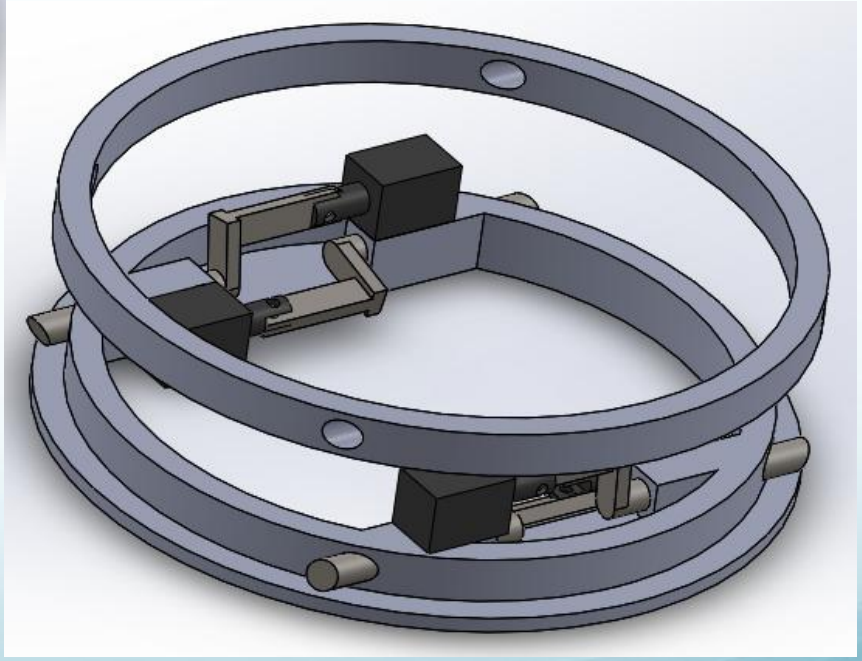
Components to be Manufactured	Team Members
Payload Ring (PR)	Jason, Alen, Ben
Rocket Ring (RR)	Kate, Mark, Matt
Keys	Jason, Alen, Ben
Solenoid (+mounting)	Mark, Matt
Springs/Magnets (+mounting)	Kate

The sub-scale model is half the original 24” diameter and all analyses are altered accordingly

Final Design



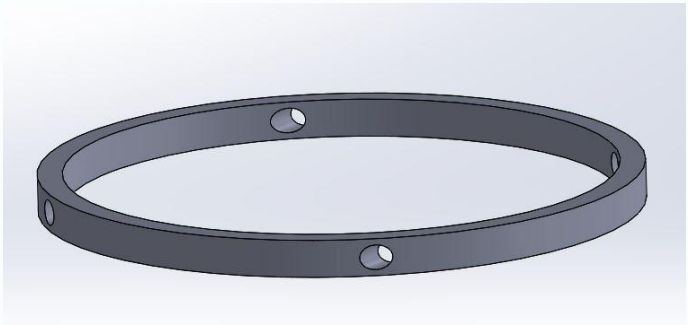
Engaged

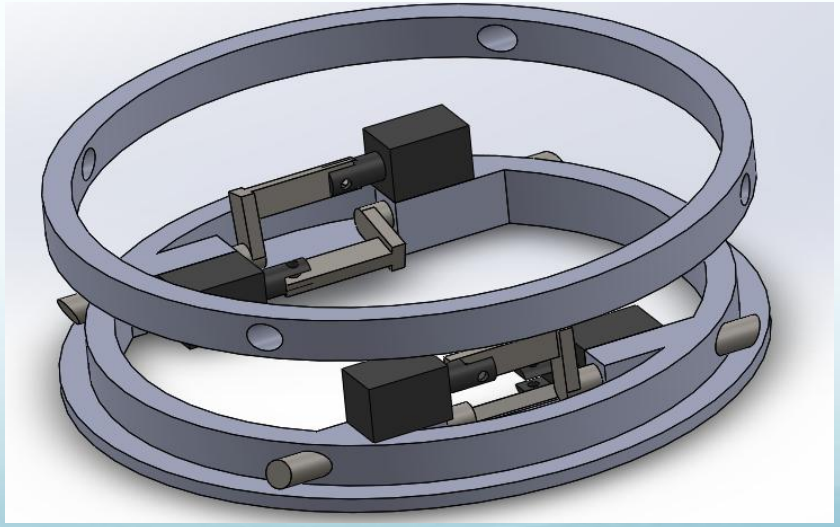


After Separation

Payload Ring

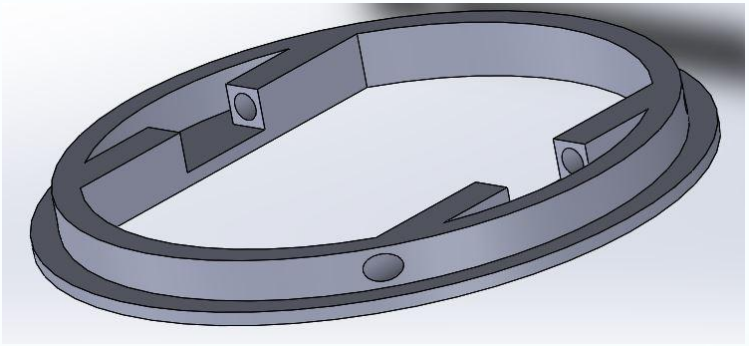
- Begin with 12” x 12” x 1” Al
- Drill 10 adaptor holes
- Inner diameter with CNC end mill
- Outer diameter with CNC end mill

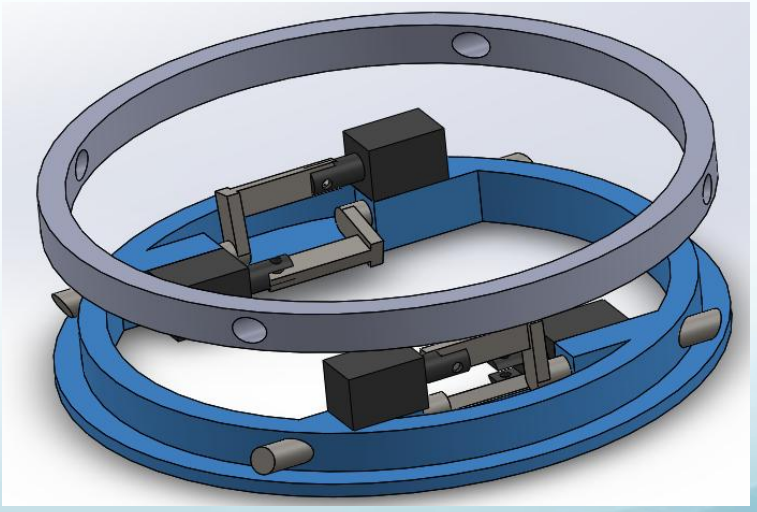




Rocket Ring

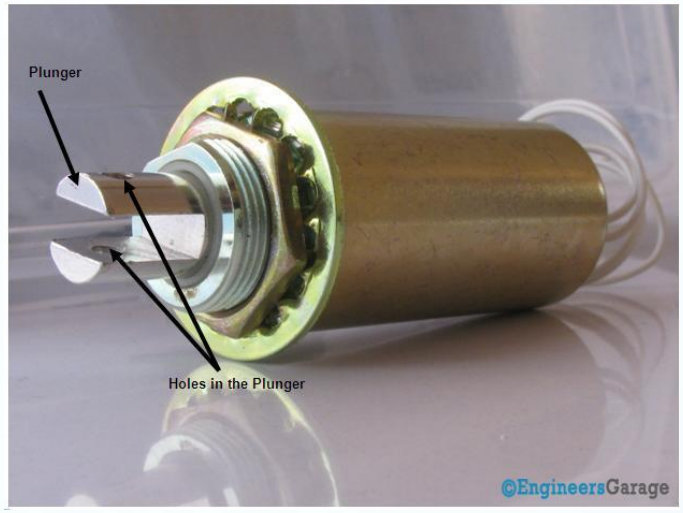
- Similar to Payload Ring
- Drill key holes into Al block
- End mill the inner surface with one CNC run
  - Key housing
  - Base plate
- End mill outer diameter keeping lip
- Cut shallow recess for spring or magnets



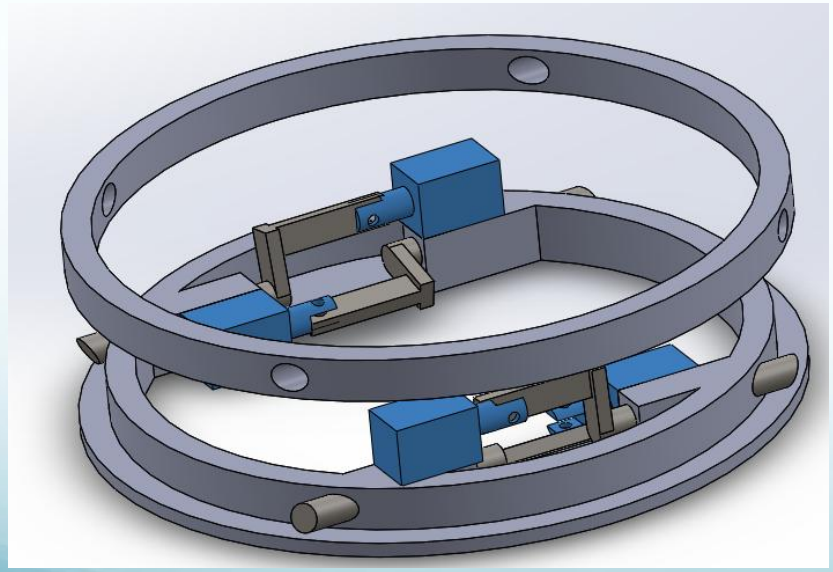


Solenoid

- Steel keys will be secured to the plunger
- Solenoid will be secured to base plate

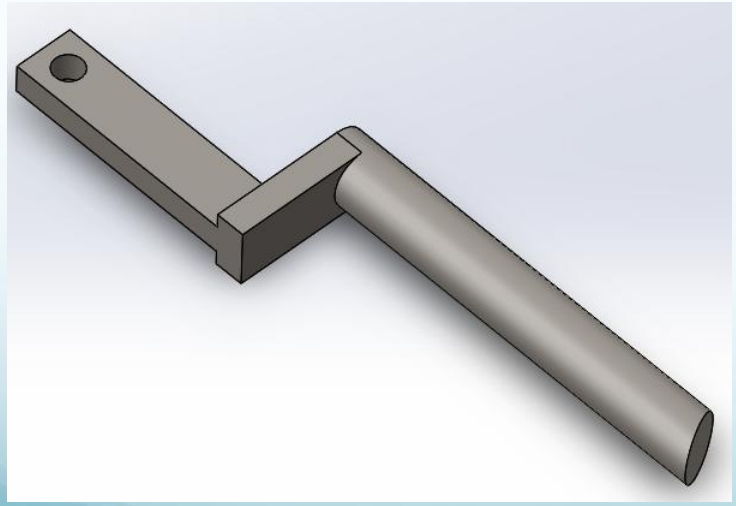


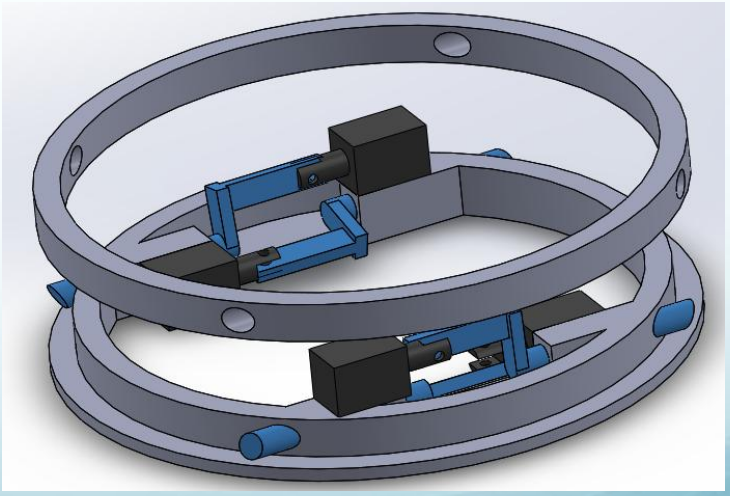
Engineersgarage.com



Manufacturing Keys

- Round 0.5” dia. steel stock
- Mill male tab to one end
- Drill hole in to tab for solenoid attachment
- Cut diagonal edge to fit into 0.5” hole





Metallic Mesh Kickoff Springs

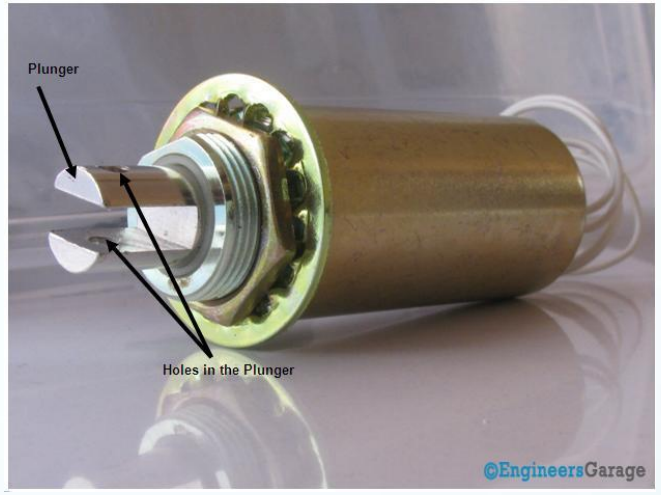
- 3 Kick off Springs placed symmetrically along the lip of the rocket ring
- Will be purchased
- The springs will sit in the recesed holes on the lip of the rocket ring

Engineering Analysis Alterations

- Solenoid Analysis
- Shear Force on cylindrical Keys
- Metallic Mesh Kickoff Springs OR Magnets

Solenoid Analysis

- Solenoid requirements:
  - DC Power
  - 1” minimum stroke
  - Overall dimensions < 1” x 1” x 2”
  - Pull force > 14 N
  - Easily mountable



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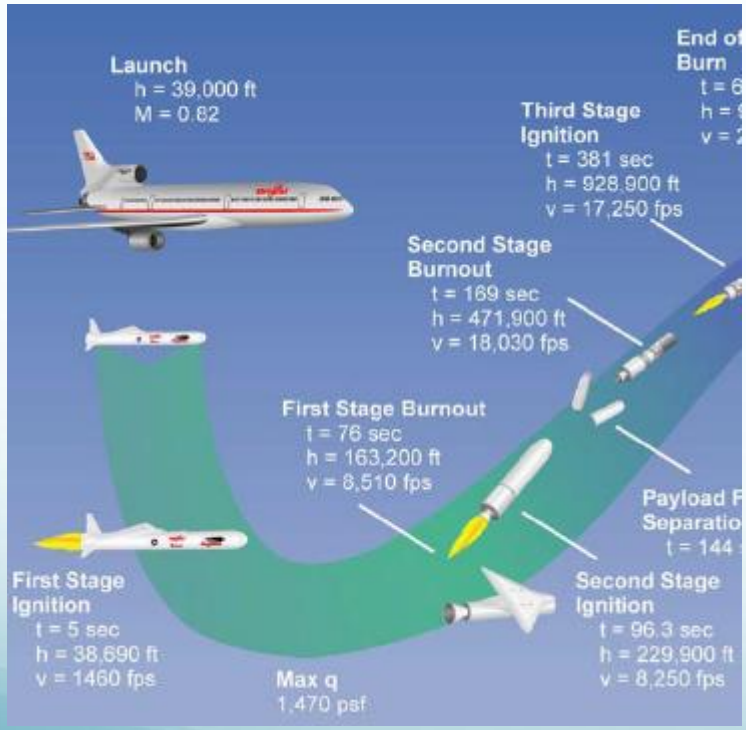
Failure Due to Shear Forces on Keys

- Note: Q = 0 once left earths atmosphere
- $Q_{max} = \frac{1}{2}\rho V^2$
  - ρ= local air density [m^3/kg]
  - V= vehicles velocity [m/s]



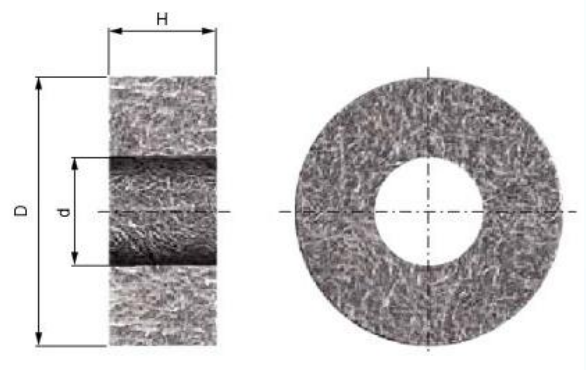
http://www.orbital.com/

Q_{max} [N/m²]	Q_{max} per Key [N/m²]
70383.6	17595.9
Top Surface Area of Key [m²]	**Cross Sectional Area [m²]**
0.000507	0.000127
Force due to Q_{max} [N]	**Force due to $M_{payload}$ [N]**
8.91	6169.21
Shear Strength [Pa]	**Shear Strength Failure [Pa]**
4.88×10^7	215×10^6
Factor of Safety	
4.41	

The stainless steel keys will not fail due to shear force caused by the first stage ignition process.

Metallic Mesh Kickoff Springs

- Material: AISI 304 Stainless Steel
- Temperature range: -90°C to +400°C
- Rocket Ring Lip: ½”
- Max Load of damped spring: 500 N
- Max Payload (300lb): 1334.47 N
  - Need 3 springs
- Static Deflection: 5.5 mm
- Weight: 7 g



http://www.weforma.com/fileadmin/pdf/1213/Weforma-Metal-Cushions-12-13.pdf

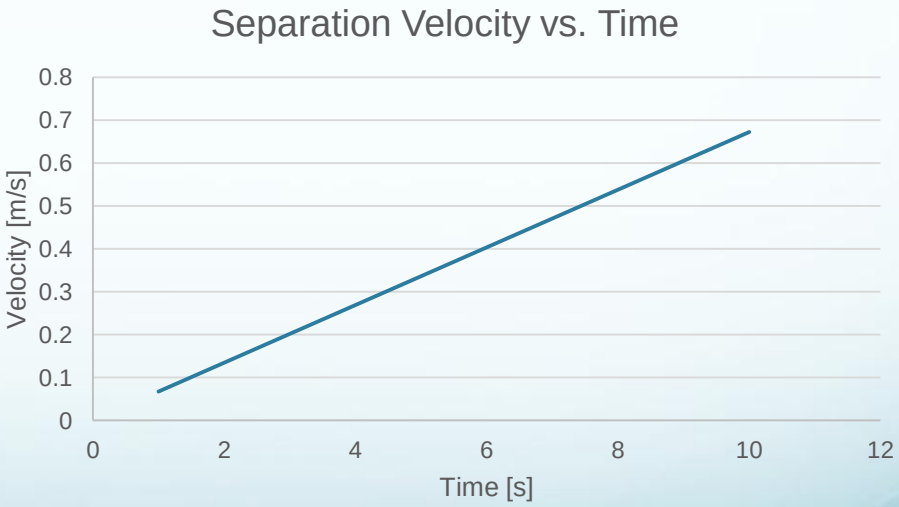
http://www.weforma.com/fileadmin/pdf/1213/Weforma-Metal-Cushions-12-13.pdf

D [mm]
22
d [mm]
6.3
H [mm]
15.5

Metallic Kickoff Springs Continued

- Natural Frequency (f_n): 15 – 20 Hz
- Stiffness per damped spring (k): 110.54 N/m
- Mass of payload: 600 lb = 272.15 kg

[Hz]	[rad/s]	m [kg]	k [N/m]
20	125.7	45.36	716283.24
ζ [ul]	**[Ns/m]**	**c [Ns/m]**	**x [m]**
1.914213562	11400.00198	21822.0384	0.0055
F [N]	**V [m/s]**	**a [m/s^2]**	
3939.56	0.69	0.067	



Neodymium Magnets

- Easy to manufacture into rings
- Allows for no gap between rings
- Up to 7lb force per 0.5” magnet

http://buymagnets.com/product/46/Neodymium-Magnet-Disc-Grade-N30-Nickel-Plated/

P.S.S. Testing

- Two Situations that need to be Tested:
  1. Prove keys can withstand max dynamic pressure (Q)
  2. Prove complete separation of a 600lb load with minimal shock
- Possible Testing Environments:
  - Submerge in Water
    - Pros: Reduces gravity
    - Cons: Solenoids aren't waterproof
  - Hang from a spring
  - Use a liquid more dense than water
  - Free fall
- Future Challenges:
  - Load 300lb?
  - Absence of Gravity

Bill of Materials

- For one 12” diameter Payload Separation System

Material	Quantity	Unit Cost
Stainless Steel Key 0.5" dia x 2’ long	1	$9.00
7075 Aluminium plate 24" x 48" x 1"	1	Donated
Solenoid	4	$32.75
Nuts/ Bolts/ Misc.	TBD	$50.00
Total Cost		**$190.00**

Man Power Cost

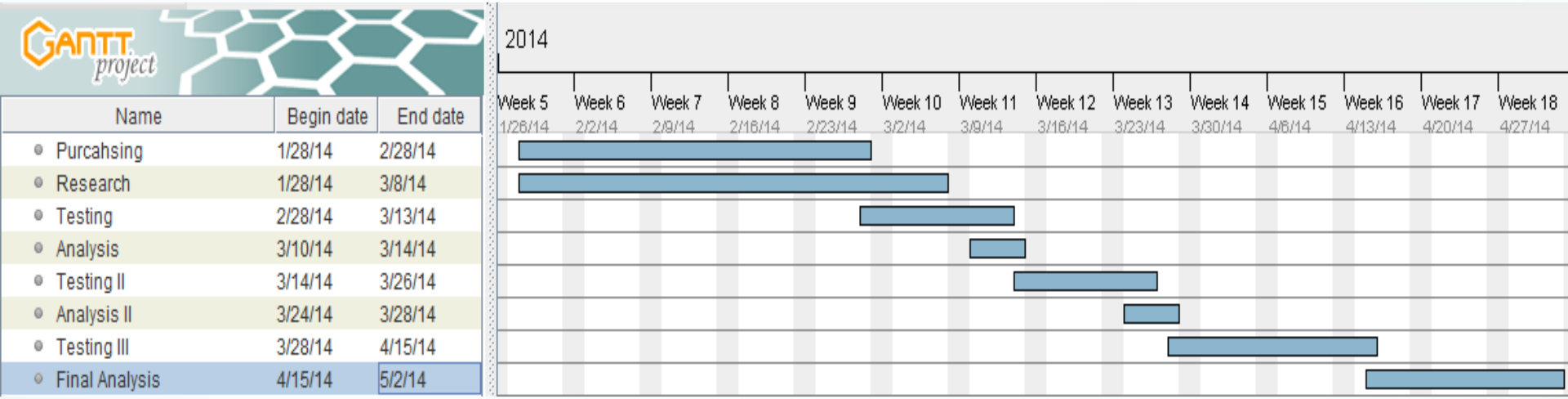
Team Members	Pay ($/hr)	Rocket Ring Fabrication (hr)	Payload Ring Fabrication (hr)	Key Fabrication (hr)	Spring Assembly (hr)	Solenoid Assembly (hr)	Assembly (hr)	Total Hours
Matthew Mylan	20	10	4	2		3	1	20
Mark Majkrzak	20	10	4		2	3	1	20
Kate Prentice	20	10	4		2	3	1	20
Alen Younan	20		10	2	3		1	16
Ben Dirgo	20		10		3		2	15
Jason McCall	20		10	2	3		2	17
	Total Cost ($)							**$2,160**

Manufacturing Costs

- All manufacturing will be in building 98C machine shop
- Part cost + man hours

	Pay ($/hr)	Man Power (hr)	Part Cost ($)	Manufacturing Cost ($)
RR	20	30	donated	600
PR	20	42	donated	840
Keys	20	6	9	129
Solenoids	20	9	32.75	212.75
			Total ($)	**1781.75**

Gantt Chart: Spring 2014



Name	Begin date	End date
Purcahsing	1/28/14	2/28/14
Research	1/28/14	3/8/14
Testing	2/28/14	3/13/14
Analysis	3/10/14	3/14/14
Testing II	3/14/14	3/26/14
Analysis II	3/24/14	3/28/14
Testing III	3/28/14	4/15/14
Final Analysis	4/15/14	5/2/14

Conclusion

- Reviewed the problem statement, contact with Orbital, and client objectives
- Used SolidWorks models to effectively communicate the final Design
- Explained how the team will ultimately manufacture each component of the PSS
- Initial separation caused by retracting the four keys using four Solenoids and metallic mesh kickoff springs to completely separate
- Performed additional analysis due to alterations of the keys, solenoids, and springs
- Re-calculated and recorded manufacturing costs, a bill of materials, and man power cost
- Explained current and future plans using a Gantt Chart

References

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Thank you for listening,

QUESTIONS?