HDRM-Final Testing Results

Team Stellar Hold

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Design Requirements

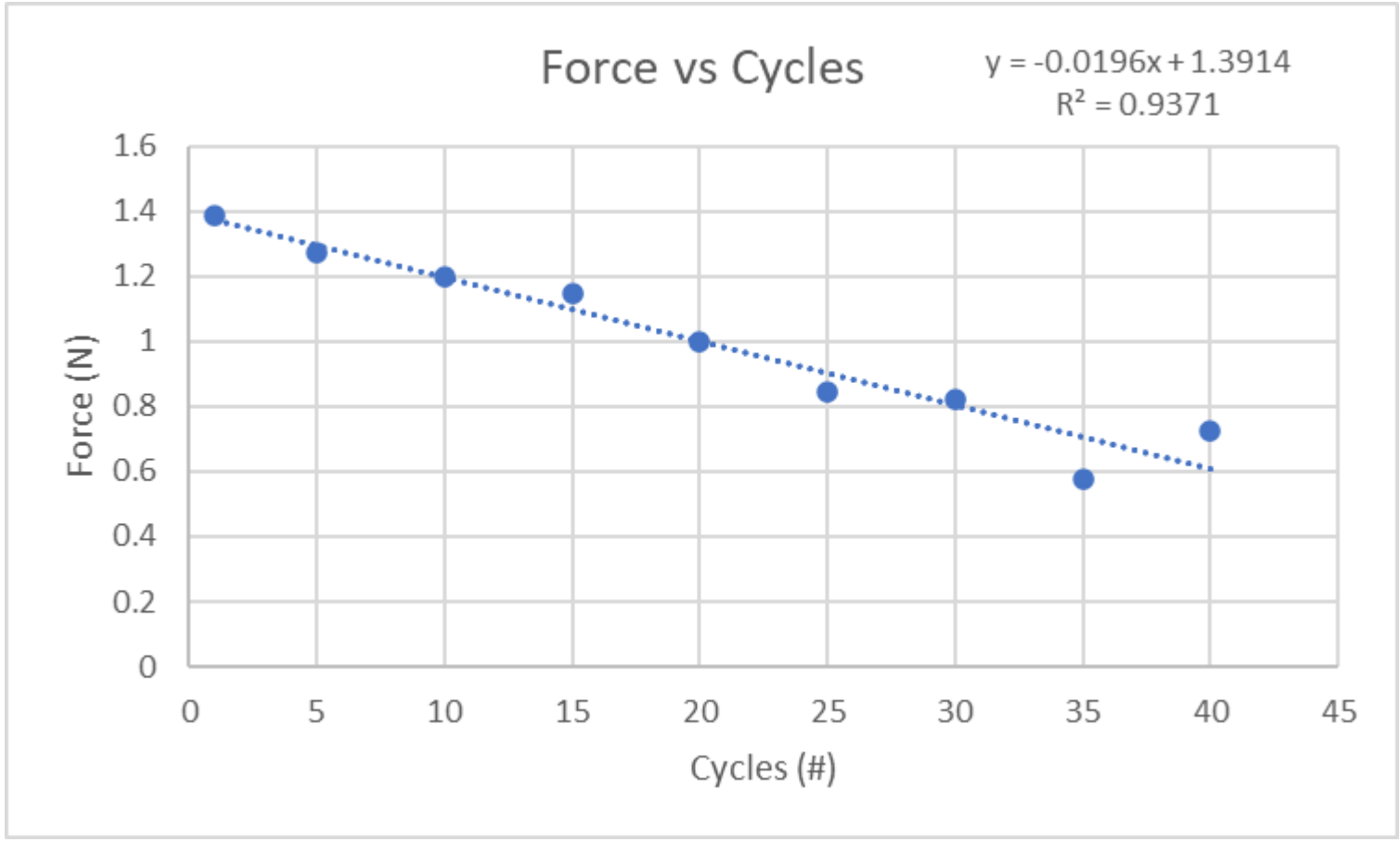
#	CR	ER
1	No Space Debris	No breakaway parts
2	Low Outgassing	Low outgassing materials
3	No Combustion	No combustion
4	20x30 cm Deploy Solar Panels	Minimize volume
5	Minimize Protruding Material	Minimize protruding material
6	Maximize Deployment Load/ Simultaneously	Maximize deployment force
7	Easily Resettable	No deformation
8	Retain Stowed Configuration prior to deployment	Maximize retention reliability
9	Receive Input Command	Receive input command
10	Minimize Weight	Minimize weight
11	Minimize Reset Time	Minimize actuation time
12		Max. SMA spring life @ 1N

Test Summary Table

Experiment #	Experiment/ Test	Relevant DRs
1	Actuation Test	ER9/CR9, ER3/CR3, CR7
2	Actuation Voltage Test	ER11/CR11
3	Spring Force	ER9
4	Shear Load Test	ER7, ER6/CR6/ER12
5	Measurement Verifications	ER5/CR5, ER4
6	Weight Verifications	ER10/CR10
7	Outgassing Verifications	ER2/CR2
8	CubeSat Deployment	CR4, ER6/CR6/CR12, CR8
9	Debris Verification	ER1/ CR1

#1 & 3: Nitinol Spring Force/ Life Cycle

Force vs Cycles		
Cycles	Output (g)	Force (N)
1	141.5	1.388115
5	130	1.2753
10	121.96	1.1964276
15	117	1.14777
20	102	1.00062
25	86	0.84366
30	83.8	0.822078
35	58.6	0.574866
40	73.9	0.724959



#2: Voltage

- Voltage: 5V
- Actuation Time: ~12 seconds

#4: Axial Load Test

Result				
Axial Force:	14.54	±	0.218	N
	3.27	±	0.049	Lbs.

One Reading (g)	Average Reading (g)	Force (N)
1514.9	1504.27	14.74
1459.4	1434.86	14.06
1454.7	1471.81	14.42
1470.7	1440.58	14.12
1505.2	1498.91	14.69
1502.7	1508.05	14.78
1514.9	1505.55	14.75
1500.8	1501.92	14.72
1495.1	1489.09	14.59
1479.7	1465.97	14.37
1495.3	1507.67	14.78
1482.3	1479.71	14.50
Average:	1484.0325	14.54

#5 Weight and #6 Measurement Verifications

- Measurements
  - **External Shaft protruding from HDRM: 7.1mm**
  - **External Shaft Protruding from CubeSat: 0.1mm**
  - Length of HDRM: 46.7mm / 1.84 in
  - Width of HDRM: 25.6mm / 1 in
  - Height of HDRM: 46.6mm / 1.84 in
  - **Volume of HDRM Shell: 3.4 in^3**
  - **Weight: 75g**

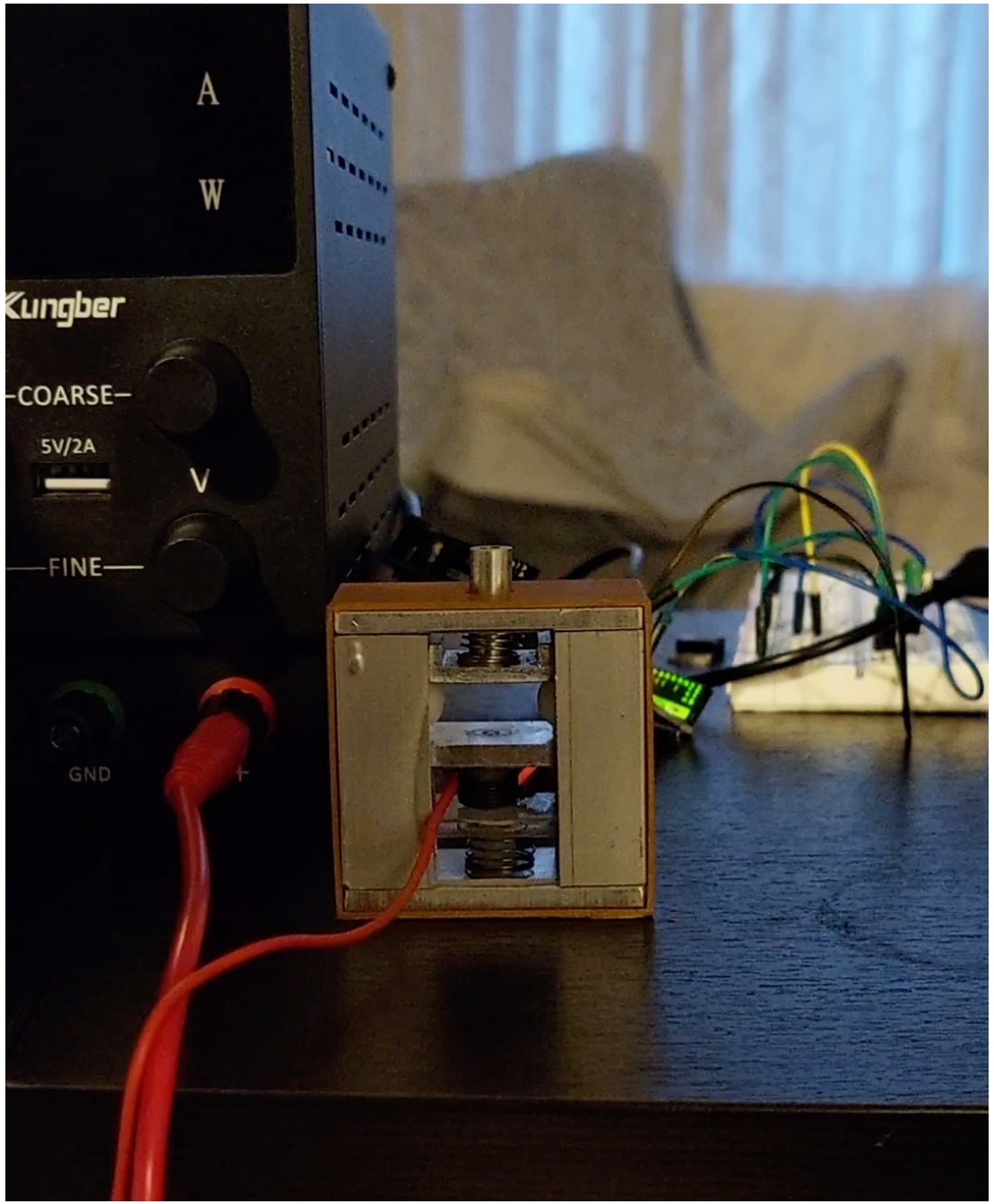
#7 Low Outgassing

- Can be tested by evaluating the materials used
- Nasa Standards:
  - Total Mass Loss < 1%
  - Collected Volatile Condensable Material < 0.1%

- Aluminum: TML = 0.15%, CVCM = 0.0%
- Teflon: TML = 0.05%, CVCM = 0.0%
- Nitinol: Unspecified but Determined OK by NASA
  - Source: https://ntrs.nasa.gov/api/citations/20140010477/downloads/20140010477.pdf
- Stainless steel spring: TML = 0.02% CVCM = 0.0%
- Vero Ultra Resin: (Expected to fail) – No data available. Expected high outgassing.
  - Replace resin with PEEK or ultem, can still use Teflon film.

#8 CubeSat Deployment

- Assessed by design
  - All panels will release simultaneously when the HDRM actuates
  - Video of action



#9 Debris Verification

- Visually assessed
- Actuation does not include any parts breaking or being removed
- No debris released

Specification Sheet Preparation

Engineering Requirement	Target	Units	Tolerance	Measured/ Calculated Value	ER Met? Y/N	Client Acceptable? Y/N
No breakaway parts	0	-	0	0	Y	Y
Low outgassing materials	0	-	0	-	N	Y
No combustion	0	-	0	0	Y	Y
Minimize volume	1	cu. In	+0.5	3.4 in^3	N	Y
Minimize protruding material	1	cm	0.1	0.1 mm	Y	Y
Maximize deployment force	25	N	- 5	14.5	N	Y
No deformation	0	%	+2	0	Y	Y
Maximize retention reliability	100	%	1.5	100	Y	Y
Receive input command	-	-	-	-	Y	Y
Minimize weight	200	g	+50 -200	75	Y	Y
Minimize reset time	30	sec	+30	15	Y	Y
Maximize SMA Spring life (1N)	50	Cycles	5	20	N	Y

Customer Requirements	CR Met? Y/N	Client Acceptable? Y/N
No Space Debris	Y	Y
Low Outgassing	N	Y
No Combustion	Y	Y
Can deploy 20x30cm panels	N	Y
Minimize protruding material	Y	Y
max deployment load / simultaneously	N	Y
Easily resettable	Y	Y
Retain stowed config prior to deployment	Y	Y
Receive input command	Y	Y
Minimize Weight	Y	Y
minimize reset time	Y	Y

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		Technical Requirements										
Customer Needs	Customer Weights	No Breakaway parts	Low outgassing materials	no combustion	minimize volume	minimize external hardware	maximize deployment force	no deformation	maximize retention reliability	must receive input	minimize weight	minimize reset time
No Space Debris	5	1		1		1			1			1
low outgassing	3		1					1	1			
No pyrotechnics	5	1	1	1				1	1		1	1
must deploy solar panels 20x30cm	3				1							
cannot protrude more than 1cm from bottom	4				1	1			-1		1	-1
Must deploy panels on all sides simultaneously	3					-1	1		1			
Must be able to easily reset	5	1		1	-1			1				1
Must be able to retained stowed config prior to launch	5					1	1		1			
must release on command	3									1		
must have rotational abilities	2								1			
Technical Requirement Units		#	%	n/a	CU IN	cm	N	%	%	n/a	g	s
Technical Requirement Targets		0.00	0.10		1.00	1cm	25	2	98.5		200	<60s
Absolute Technical Importance		15.0	8.0	15.0	2.0	11.0	8.0	13.0	19.0	3.0	9.0	11.0
Relative Technical Importance		3	2	3	1	2	2	3	5	1	2	2