Hold Down and Release Mechanism (HDRM)

Sponsored by General Atomics – Electromagnetic Systems

Team 4: STELLARHOLD – Valentin Gamez, Nathan Olson, Maia Warren

Project Description

- General Atomics-*energy and defense corporation (nuclear research)*
- HDRM serves as part of GA-EMS spacecraft in-house mission

  - Sponsored by GA

  - Supplied to GA by outside vendors *(beginning in-house development)*

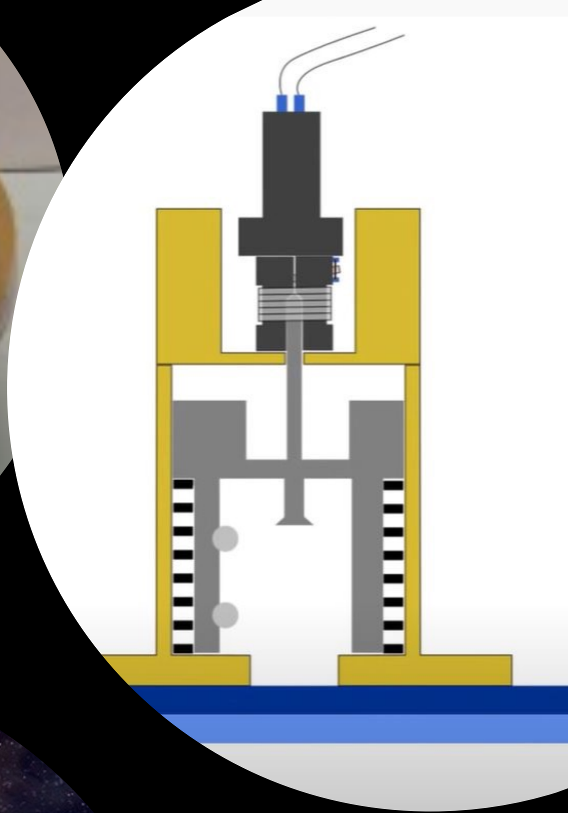
- Parts stowed during deployment, released once in orbit *(detumble stage)*

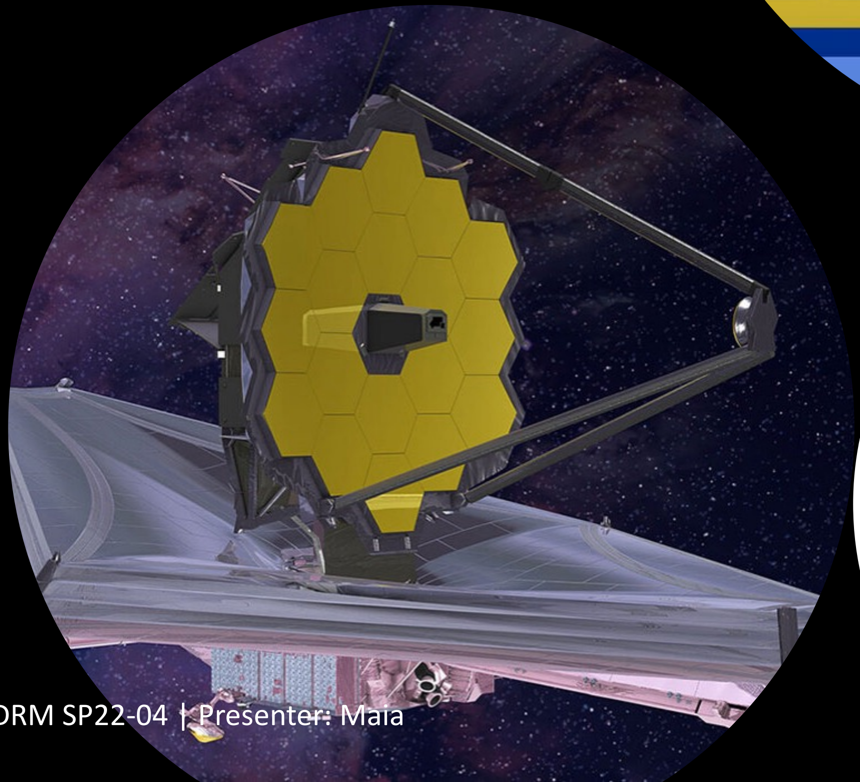
  - Solar panel arrays, rolls, antennas, etc.

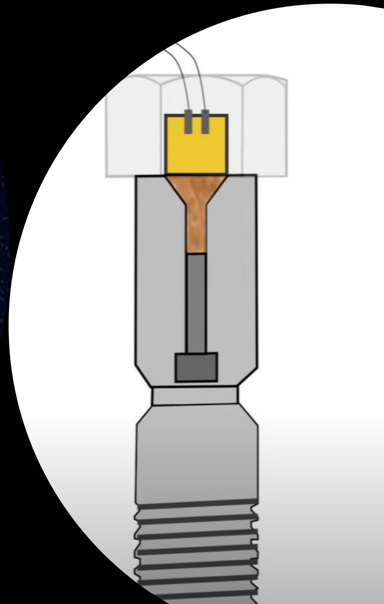
  - Intended to be put on CubeSats

- **Why are HDRMs needed?**
- Mentor/meetings with GA to help with customizing components

  - mix of 3D printed mechanical and electrical design







Background and Benchmarking

- Pyrotechnic HDRM
  - When released a reaction is activated that causes different levels of explosions that lead to breaking a bolt and releasing the device.
- First-MOVE CubeSat mission successfully used a Single-Shot HDRM (Figure 1)
  - Melted Dyneema string released
  - First-MOVE's goal to improve the design is to make it easier to reset and be used repeatedly.

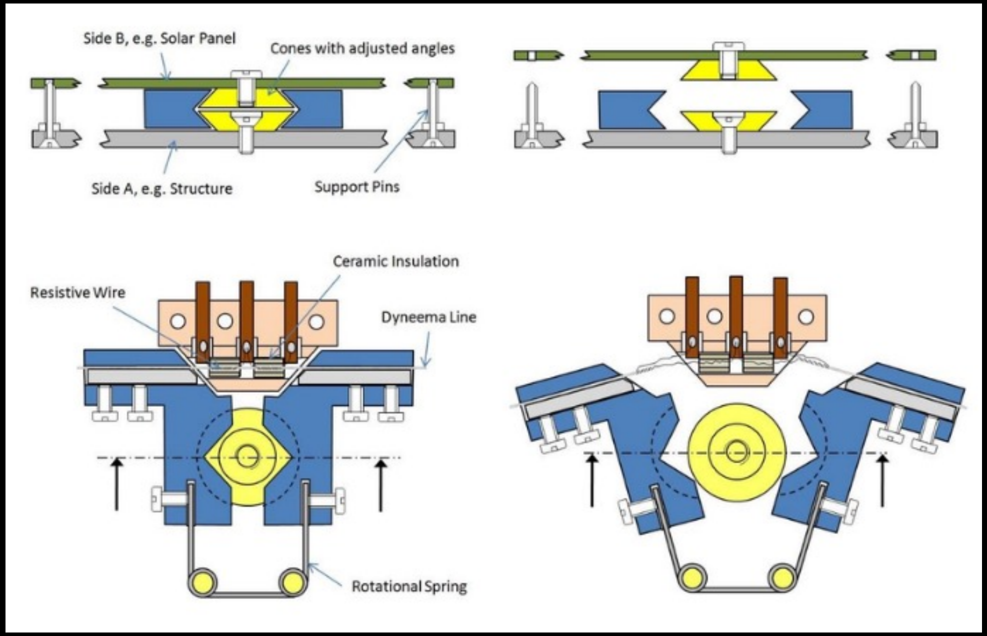


Figure 1: Single Shot HDRM [1]

Background and Benchmarking

- HDRM called REACT is resettable and based on Shape-Memory Alloy (SMA) technology (Figure 2)
  - SMA: alloy that can deform in cold temperatures and pre-deform when heated.
- Replaces pyrotechnic (explosive method) with SMA actuator
  - Easy to reset (Done automatically)
  - Efficient testing methods (repeat)

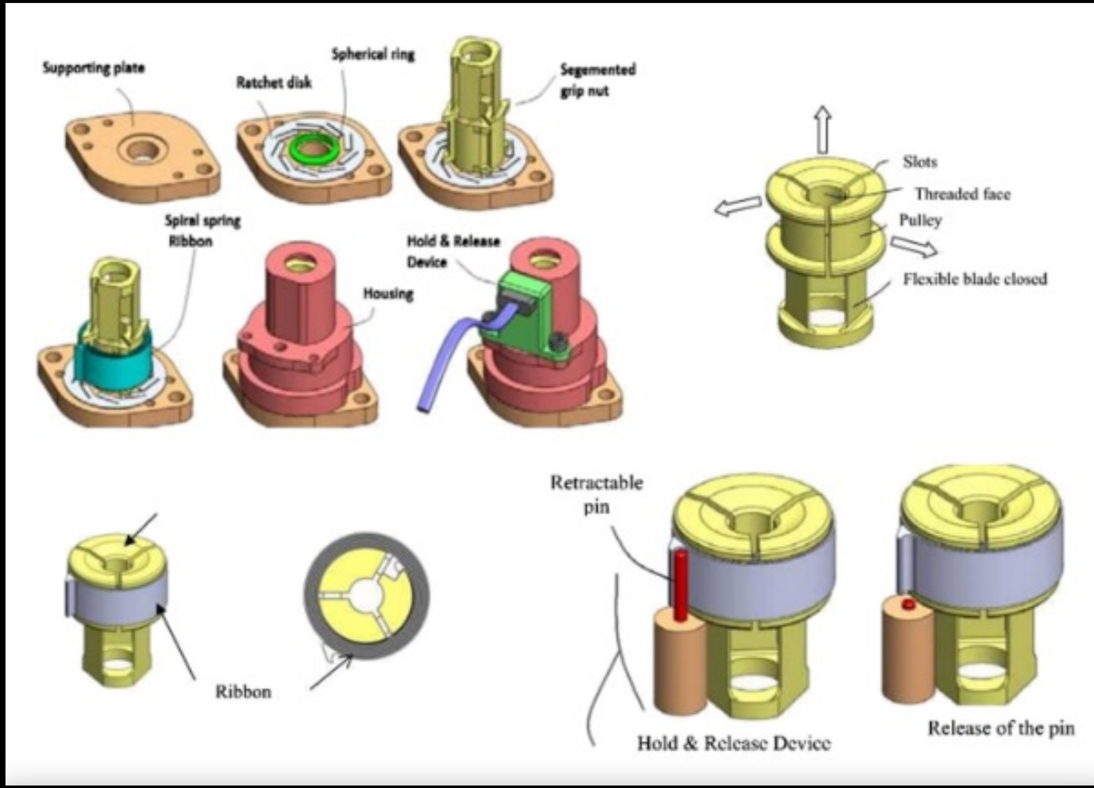


Figure 2: REACT HDRM [2]

Literature Review

- G.A. CubeSat Team, NAU ME Capstone, 2021. [Online]. Available:https://www.ceias.nau.edu/capstone/projects/ME/2020/20Spr2_GACubesat/ [Accessed February 2, 2022].
    - *The previous capstone group that worked with General Atomics built a CubeSat which is the base that we are building the HDRM for. Working through the previous team's website allowed us to understand where we might connect the HDRM and what parts we may be responsible for releasing while the CubeSat is in orbit.*

- "NEA® hold Down & Release Mechanisms (HDRM)," *Ensign-Bickford Aerospace & Defense*, 11-Jan-2022. [Online]. Available: https://www.ebad.com/nea-hold-down-release-mechanisms-hdrm/#1562267018138-ae149058-3c03b4fc-1b51. [Accessed: 03-Feb-2022].
    - *EBAD is leading company regarding non-pyrotechnic Hold Down & Release Mechanisms for spacecrafts. This resource will provide inspiration for new ideas and guidance on different HDRM designs.*

Literature Review

- W. J. SPARK, “Hold down and release mechanism for a deployable satellite solar panel,” 23-Feb-2021.
  - *This recent patent on a HDRM for a deployable satellite solar panel will be key towards inspiring new ideas for a design and where to approve upon.*

- “Mechanical Engineering Branch,” *NASA*. [Online]. Available: https://mechanical-engineering.gsfc.nasa.gov/designref.html. [Accessed: 03-Feb-2022].
  - *As both the CAD and Manufacturing lead, Valentin Gamez will use this source for designing and manufacturing the Hold Down and Release Mechanism. With information on materials and testing, this source will help the team succeed in multiple areas.*

Customer Needs

- No space debris
- Low outgassing
- No pyrotechnics
- 10mm depth, 90º deployment angle
- Deploy on all sides
- Must be resettable
- Release on command
- Must retain stowed configuration prior to deployment

Figure 3: General Atomics [3]

Engineering Requirements

- No breakaway parts
- Low outgassing materials (if nonmetal)
- No combustions
- Cannot extend 1cm from bottom of CubeSat
- Maximize deployment force
- No deformation
- Maximize retention reliability when panels are held down
- Must be able to receive input

QFD

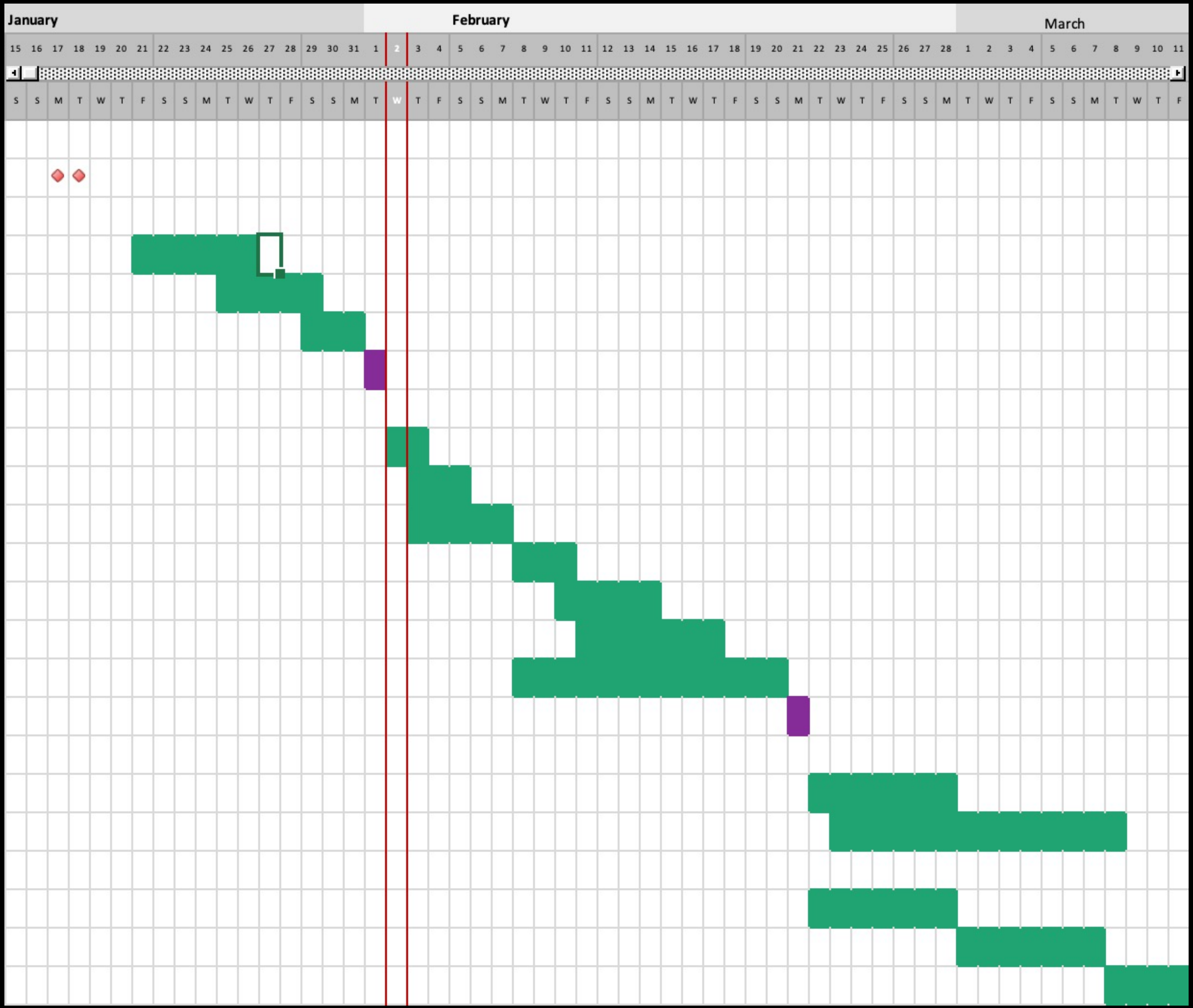
		No Breakaway parts	Low outgassing materials	no combustion	must deploy solar panels 20x30cm	cannot protrude more than 1cm from bottom	maximize deployment force	no deformation	maximize retention reliability	must receive input	deploy angle of 90°
No Space Debris	4	1	0	1	0	1	0	0	1	0	0
low outgassing	3	0	1	0	0	0	0	-1	-1	0	0
No pyrotechnics	4	1	1	1	0	0	0	0	-1	0	0
Minimize Cross-Section	4	0	0	0	1	0	-1	0	-1	0	0
Minimize thickness	4	0	0	1	0	1	-1	0	-1	0	0
Must deploy panels on all sides simultaneously	5	0	0	1	0	-1	1	0	1	0	0
Must be able to easily reset	4	1	1	1	0	0	0	1	0	0	0
Must be able to retained stowed config prior to launch	5	0	0	0	0	1	0	1	1	0	0
must release on command	5	0	0	0	0	0	0	0	1	1	0
must have rotational abilities	5	0	0	0	0	0	1	0	1	0	1
		n/a	%	n/a	cm	cm	N	mm	n/a	n/a	n/a
					20cm, 30cm	1cm	40N	TBD			90°
		12.0	11.0	21.0	4.0	8.0	2.0	6.0	9.0	5.0	5.0
		3	3	5	1	2	0	1	1	1	1

Schedule

Part 1: intro				
Team Charter	Goal	**100%**	1/17/22	2
Meeting w/ GA Rep	Presentation	**100%**	1/21/22	1
SOTA/Trade Study / background	On Track	**25%**	1/21/22	6
QFD & Problem Definition	On Track	**10%**	1/25/22	5
Presentation prep & Memo	On Track	**30%**	1/29/22	3
Presentation 1	High Risk	**0%**	2/1/22	1
Part 2: Concept Generation & Selection				
Black Box	On Track	**0%**	2/2/22	2
Sketches	On Track	**0%**	2/3/22	3
Concept Generation	On Track	**0%**	2/3/22	5
Concept Selection (decision Matrix & Pugh)	On Track	**0%**	2/8/22	3
CAD	On Track	**0%**	2/10/22	5
Budget Planning & BOM	On Track	**0%**	2/11/22	7
Presentation prep	On Track	**0%**	2/8/22	13
Presentation 2	High Risk	**0%**	2/21/22	1

Part 3: Final Presentation				
Preliminary report	On Track	**0%**	2/22/22	7
website	On Track	**0%**	2/23/22	14
analytical analysis memo	On Track	**0%**	3/16/22	7
FMEA & DFMA	On Track	**0%**	2/22/22	7
Prototype manufacturing	On Track	**0%**	3/1/22	7
Testing	On Track	**0%**	3/8/22	6
Presentation prep	On Track	**0%**	3/22/22	7
Final Presentation	High Risk	**0%**	3/29/22	1
Part 4: wrap-up				
Final Report	On Track	**0%**	4/1/22	5
Final CAD/BOM	On Track	**0%**	4/5/22	7
Final Prototype	On Track	**0%**	4/19/22	7
Prototype Demo	High Risk	**0%**	4/26/22	1
Final Website Check	On Track	**0%**	4/27/22	7
			2/2/22	2

Schedule



Budget

Total estimated budget: $5,000

- Manufacturing

  -$2,000 for HDRM

  - *initial materials*
  - *machine use (3D printer)*
  - *repairs*
  - *extra materials*

- Travel

  - $3,000 (estimated)

  - *Gas/Parking*
  - *Flights to Oxford, MS*
  - *Hotel*
  - *Ride from Tupelo to Oxford*
  - *Ubers to and from GA*

References

[1] "Results and lessons learned from the cubesat mission first ..." [Online]. Available: https://www.researchgate.net/publication/281621099_Results_and_lessons_learned_from_the_CubeSat_mission_First-MOVE. [Accessed: 03-Feb-2022].

[2] N. Nava, M. Collado, and R. Cabás, "React: Resettable hold down and release actuator for space applications," *Journal of Materials Engineering and Performance*, vol. 23, no. 7, pp. 2704–2711, 2014.

[3] "Satellites," *General Atomics*. [Online]. Available: https://www.ga.com/space-systems/satellites. [Accessed: 03-Feb-2022].

Thank you!
Questions?