National Aeronautics and Space Administration

FY24 Topic Areas Research and Technology Development (TRTD)

Additive Manufacturing of Compliant Mechanisms for Deployable Structures

Principal Investigator: Christine Gebara (355)
Co-Investigators: Maya Roman (355), Adrian Cheng (357), Stewart Sherrit (355), John Oswald (355)

Strategic Focus Area: Additive Manufacturing, Multifunctional Systems

Objective

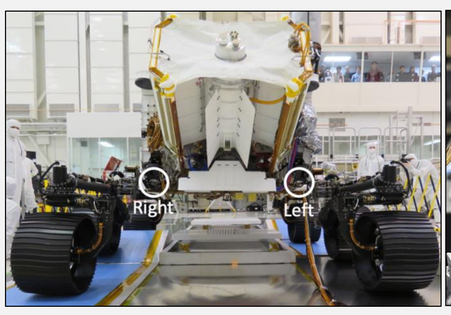
1 - Evaluate and demonstrate where **additive manufacturing** can be leveraged **to improve compliant mechanisms** within deployable aerospace structures.

2 - Evaluate the Mars 202 Camera Cover Mechanism to determine where additive manufacturing can provide performance and part count improvements.

3 - Evaluate Fast-Steering Mirror Mechanisms to determine where additive manufacturing can provide cost reduction and performance benefits comparted to wire EDM methods.

M2020 HazCams

M2020 Rear HazCam Location

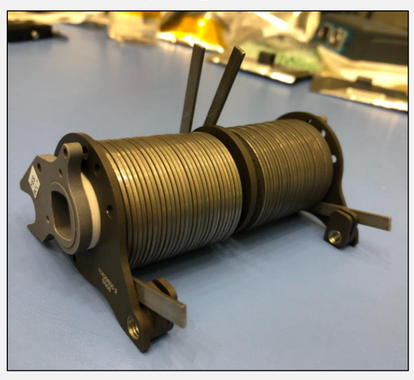


CGI Fast-Steering Mirror

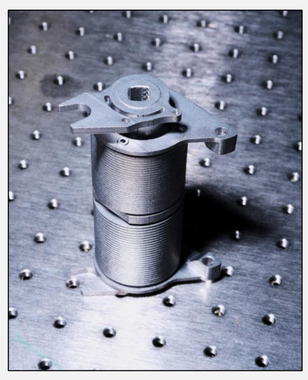
Background

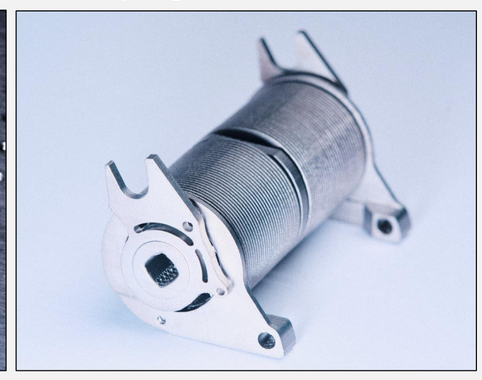
- Additive Manufacturing (AM) allows for the relaxing of design constraints that have limited JPL's ability to design high-performance deployable systems.
- AM has been demonstrated to allow for novel compliant mechanism designs.
- AM materials and manufacturing presents unique challenges for material properties and fatigue life.
- State of the art design for additive manufacturing methods do not generally include compliance.
- Ability to minimize part count and simplify manufacturing methods results in large cost savings for projects.

NISAR Spring Mechanism



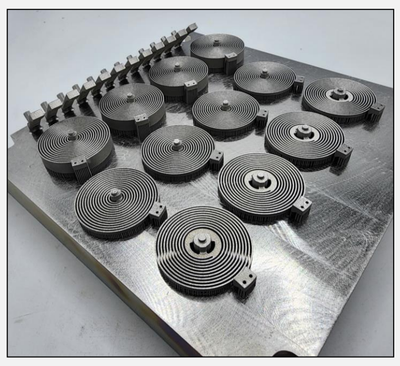
Titanium Monolithic Spring Mechanism

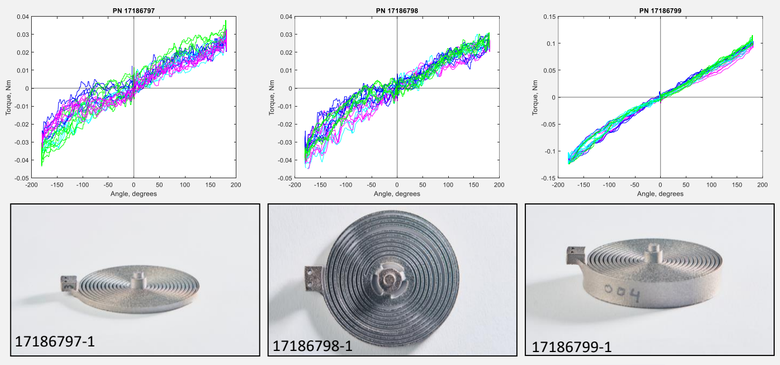




Approach And Results

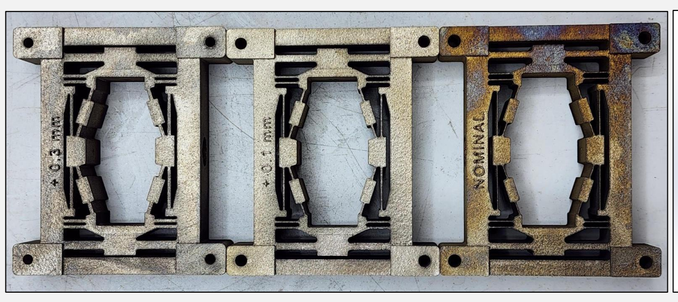
- Clock springs were design, printed, and tested to evaluate empirical performance comparted to design.
- Using test data, spring design was incorporated into a new, additive-enabled spring design.



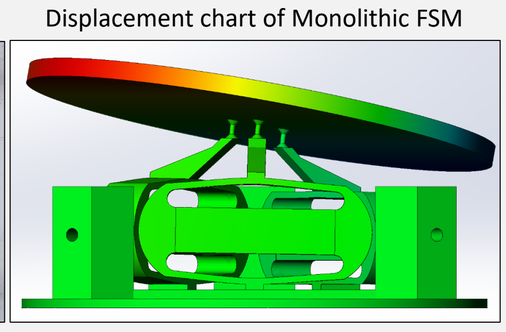


- AM of Fast-Steering Mirror (FSM) flexures allows for flexures to be fabricated more quickly and cost-effectively then traditionally.
- CGI FSM was used as a test piece, hardware was printed and post-processed successfully.

CGI Flexures Printed in Titanium

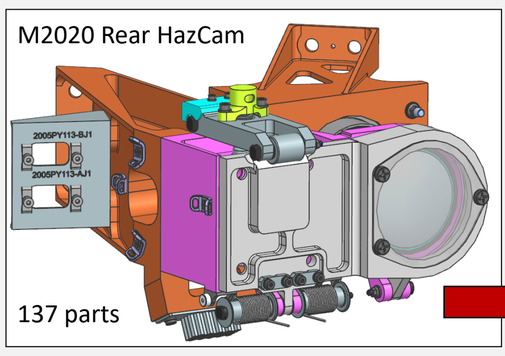


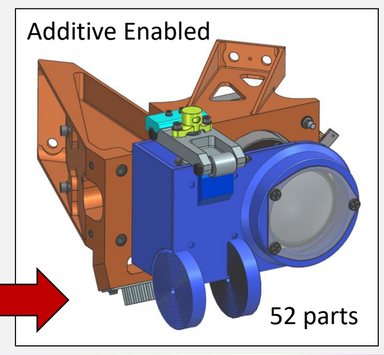
Displacement chart of Monolithic FSM



Significance to JPL and NASA

- Additive enabled camera cover design significantly minimizes weight and part count.
- Reducing part count increases reliability and workmanship errors.
- Future potential to further embed release actuator SMA.
- Work can be extended to numerous types of mechanisms.

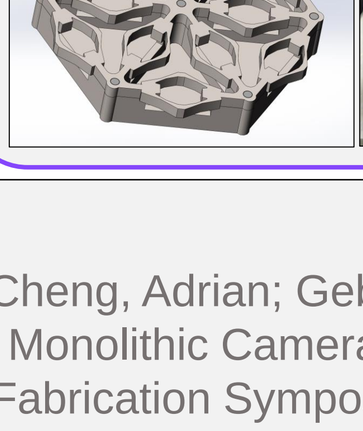


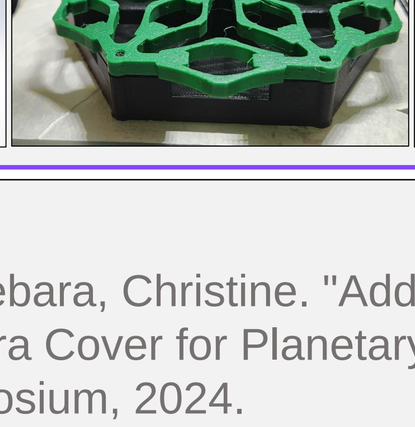


	M2020 Camera Cover	AM-Enabled Camera Cover
Part count	137	52
Mass (kg)	~0.66	~0.45

- Additive-enabled flexures reduce cost by a factor of 5+.
- Additive design enables 3-5x larger range of motion (+/- 0.78 deg).
- For optical instruments under development additive flexures may allow designs to be validate quickly and at very low cost (<$10k).

Active Optic Actuator Plate also has Similar AM Benefits





Monolithic Fast Steering Mirror

National Aeronautics and Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

www.nasa.gov

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Publications:

Roman, Maya; Cheng, Adrian; Gebara, Christine. "Additive Manufacturing of a Deployable Monolithic Camera Cover for Planetary Exploration." Solid Freeform Fabrication Symposium, 2024.

PI/Task Mgr. Contact Information:

Christine Gebara – Christine.A.Gebara@JPL.NASA.gov