Development of a Compliant Tensegrity Structure for Aerial-Terrestrial Hybrid Robotics

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01

Background & Motivation

Hopcopters and tensegrity

The Hopcopter

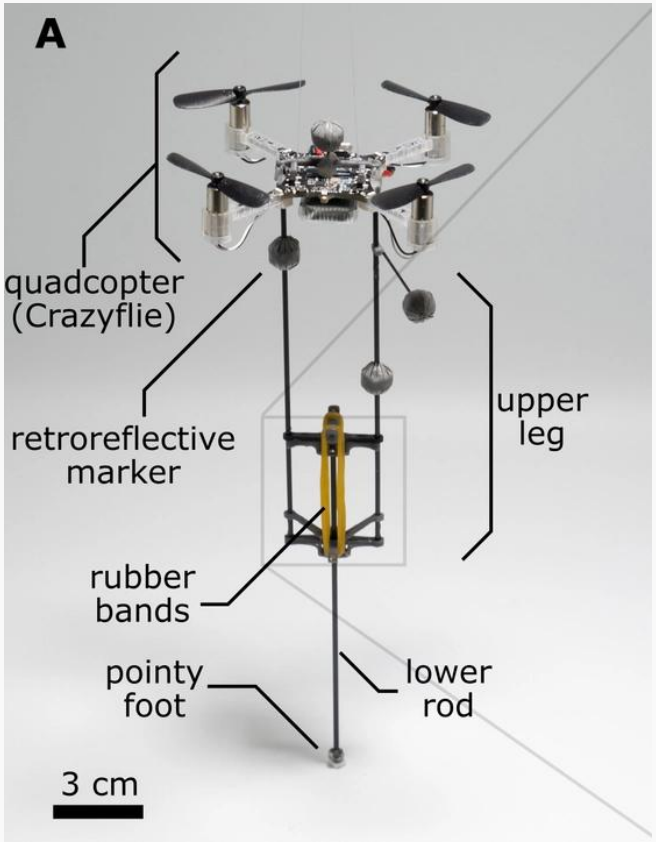


Figure 1. Hopcopter breakdown [1]

- Hybrid aerial terrestrial traversal
- 1 DoF passive telescoping leg
- Elastomers allow energy storage during terrestrial phase
- Top-heavy mass distribution

Basic Control Scheme

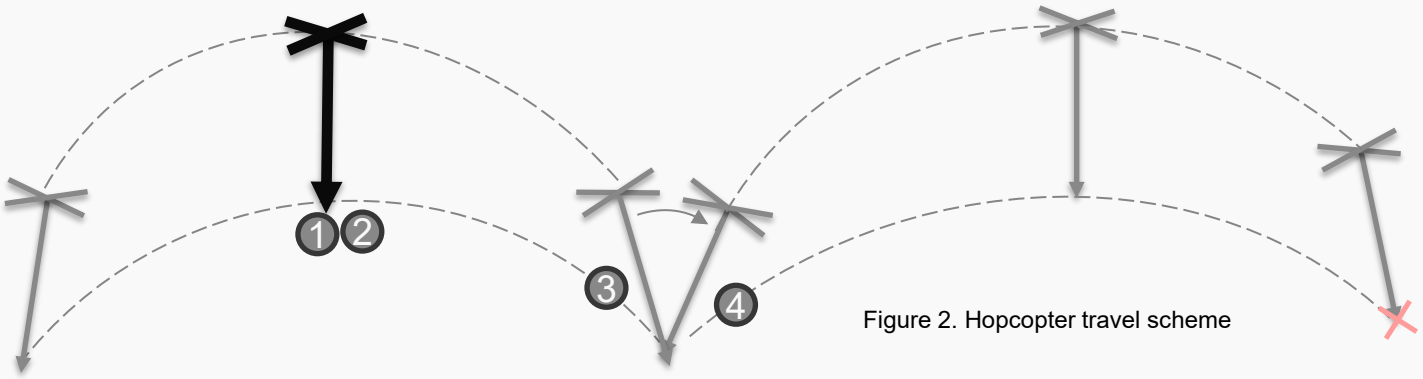


Figure 2. Hopcopter travel scheme

1. Ballistic trajectory prediction at apex
2. Iteratively calculate landing attitude for next jump
3. Pivot airframe to land in desired orientation
4. Passive stance phase

Tensegrity Systems

- Rigid struts suspended in network of cables
- Pure axial loading holds equilibirum
- Load diffusion prevents local weak points
- High stiffness-mass ratio

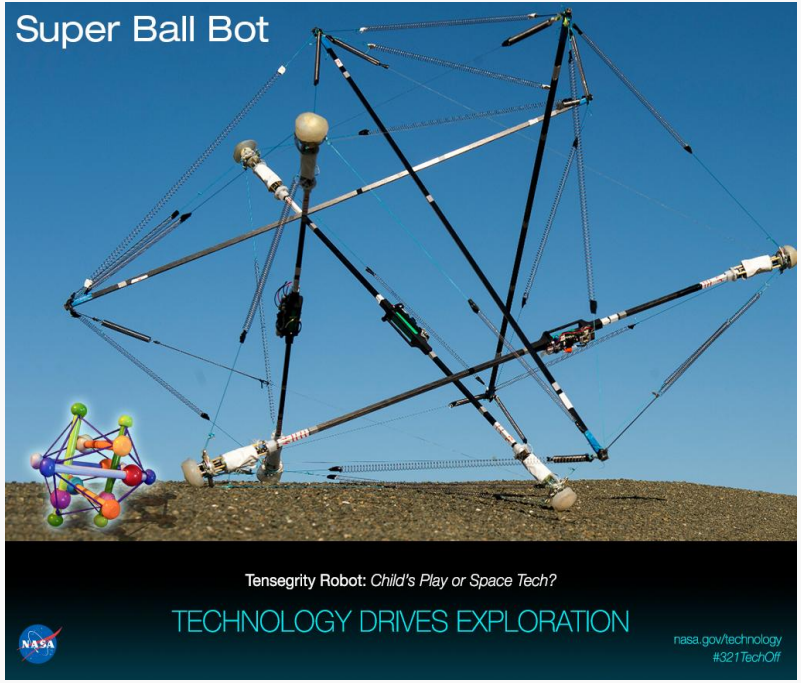


Figure 3. NASA's super ball bot, an application of tensegrity [2]

3 Strut Prism

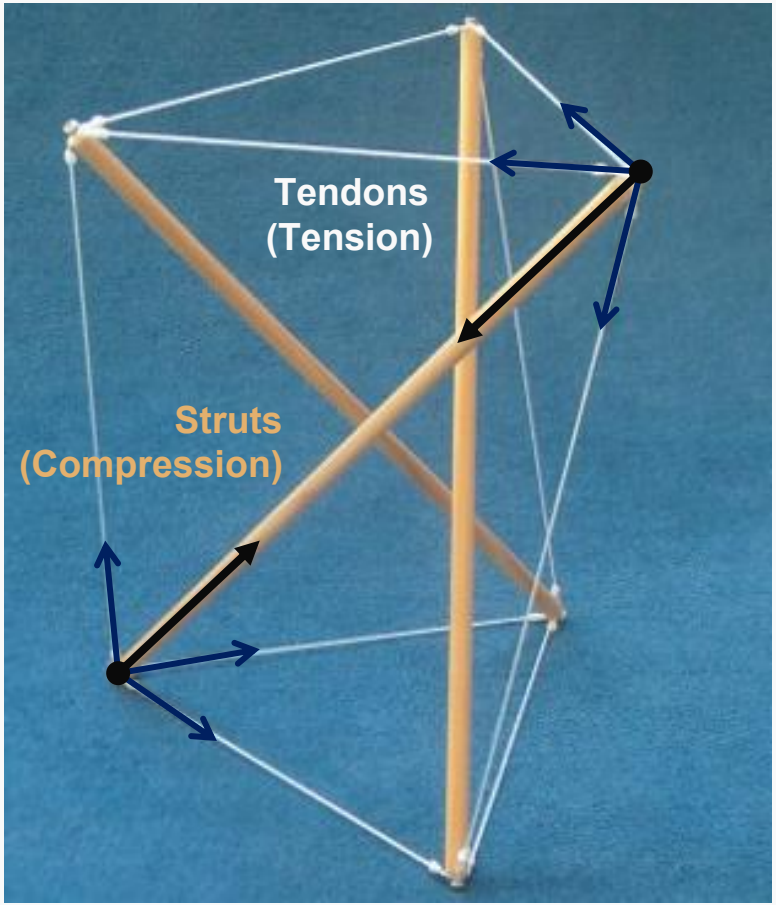


Figure 4. Simple class 1 3 strut prism tensegrity

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Physics Engine and Simulations

RK4 Physics Simulation

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Simulation Outputs



Form Finding

Evaluate equilibirum of given tensegrity structure



Physics Engine

Simulate dynamic axial loads, ground contact, friction



Data Tracking

Track and write kinetic and kinematic data throughout simulations

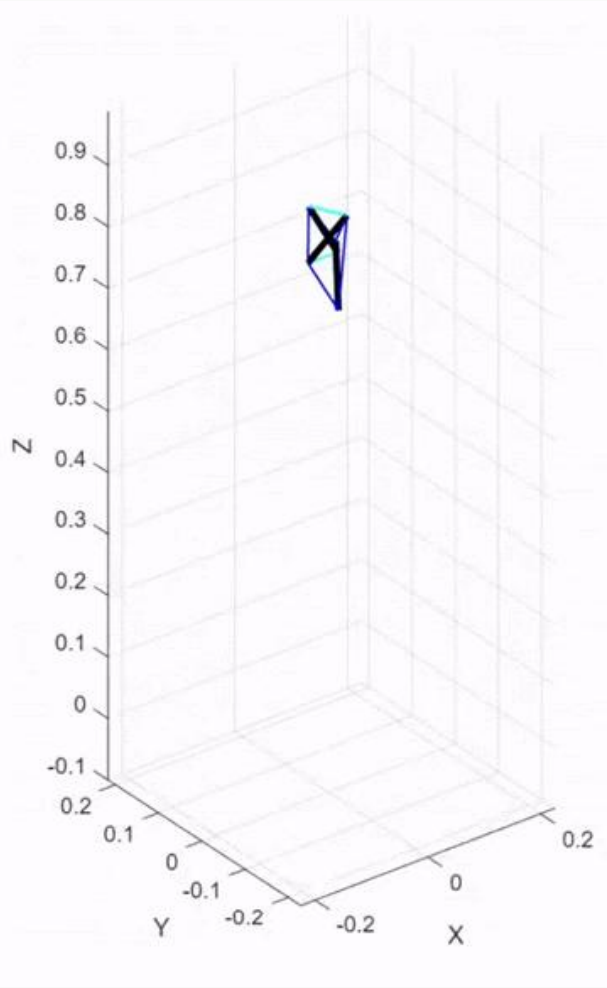
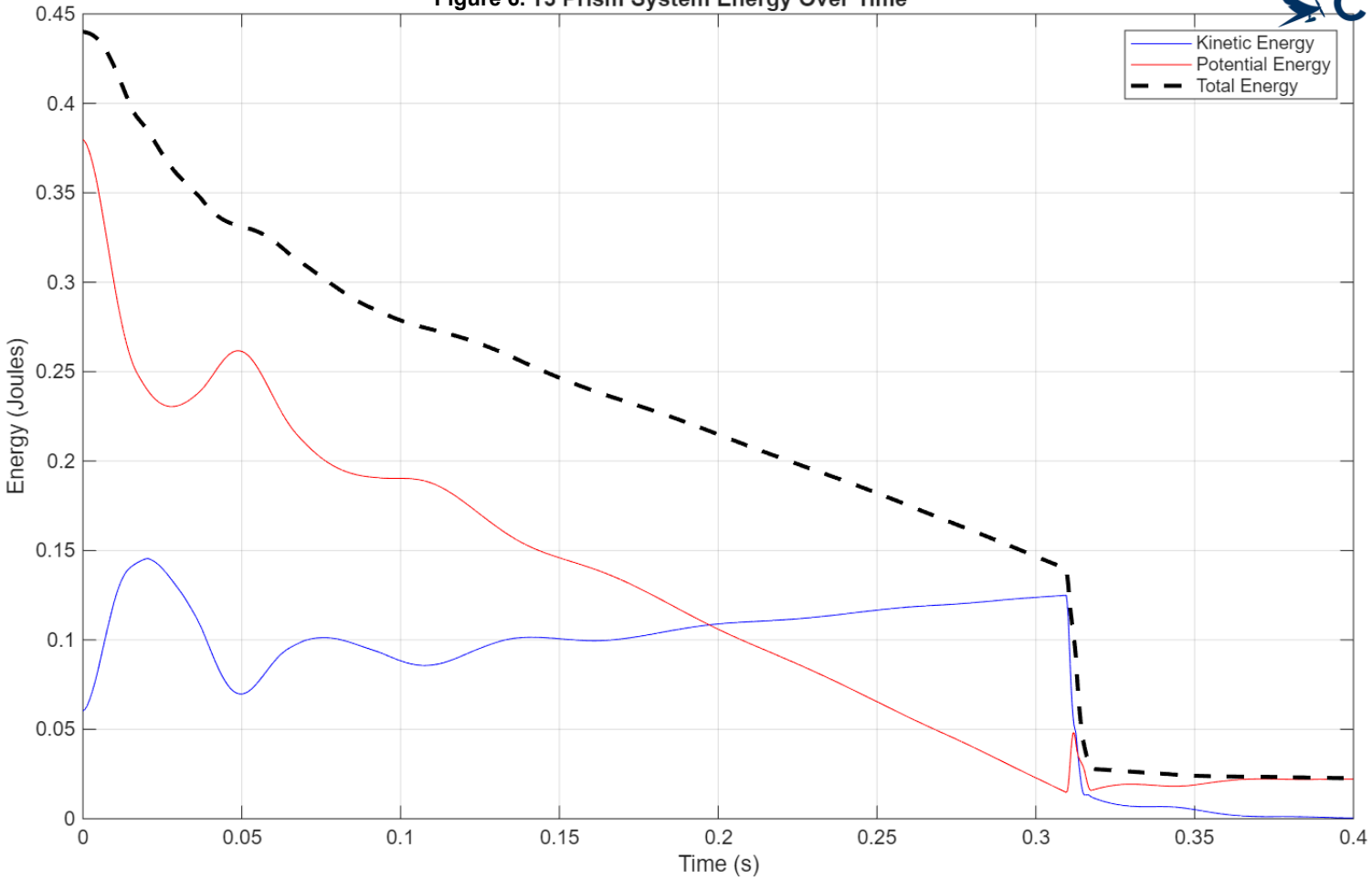


Figure 5. Sim visualization for all three goals.

Figure 6. T3 Prism System Energy Over Time



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Prototyping

Tensegrity Ring Design

Design Directions



Figure 7. Actuating Leg

Actuated Leg

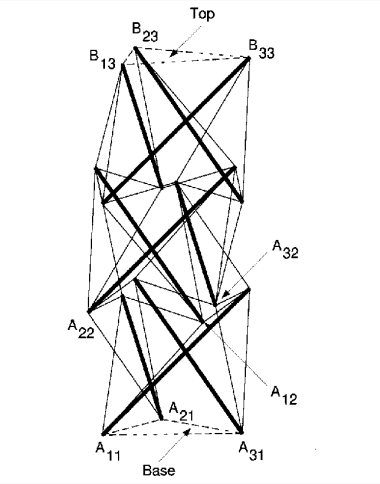


Figure 8. 2 stack 3 strut prism [3]

Multi-Point Contact

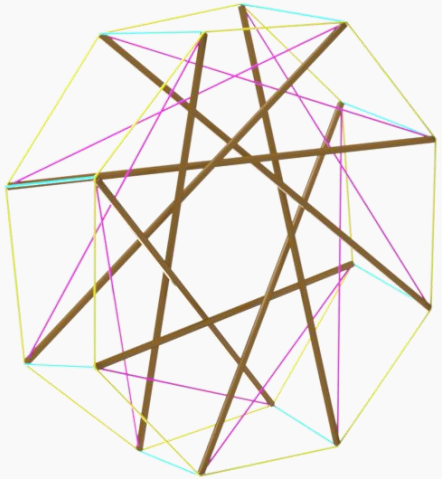


Figure 9. Buckminster fuller sphere [4]

Rolling Frame

Final Design Breakdown

Figure 10.A. Tensegrity Wheel Rim



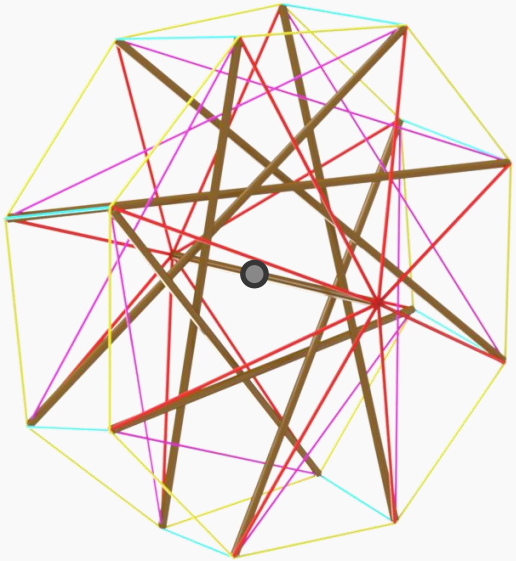
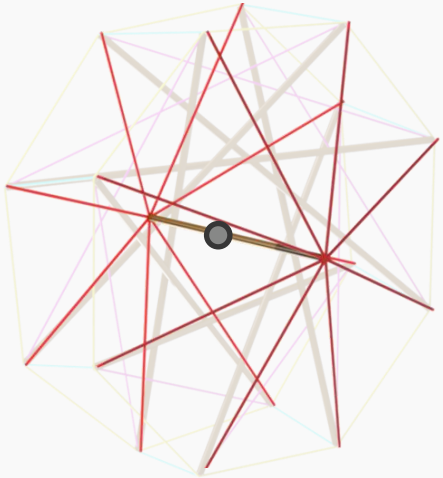
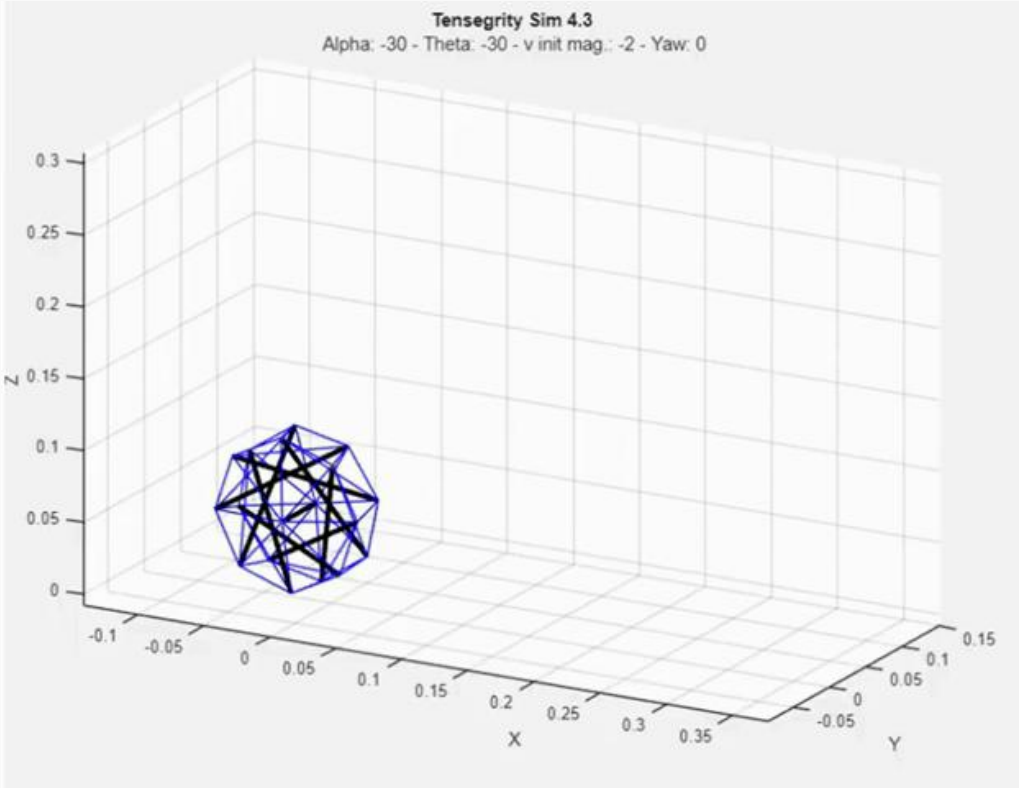


Figure 10. Final Structure

Figure 10.B. Payload Attachment Axle



Final Design Breakdown



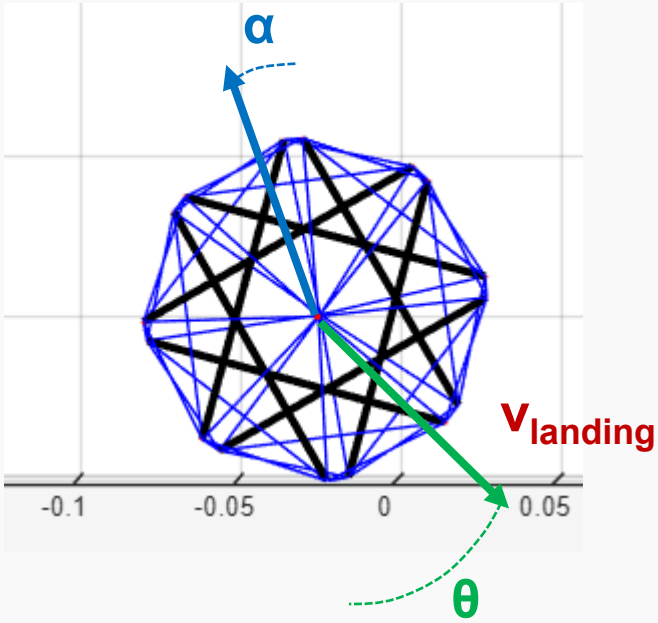


Figure 11. Tensegrity Wheel Demo and orientations

Final Design Breakdown (Stroke)

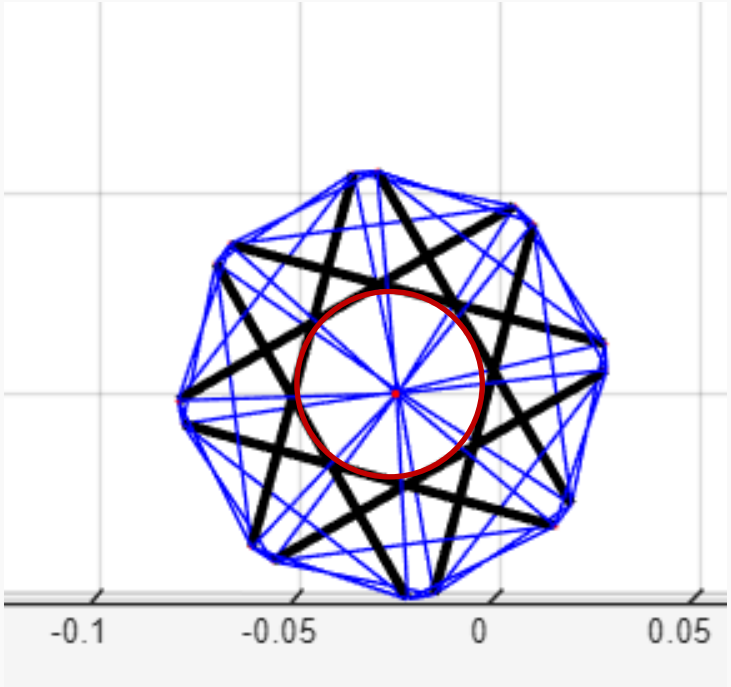


Figure 12. Stroke area visualization

- 8 strut prism base
- Strut count balanced between radial stiffness /mass and **rolling efficiency/stroke length**

Final Design Breakdown (Radial)

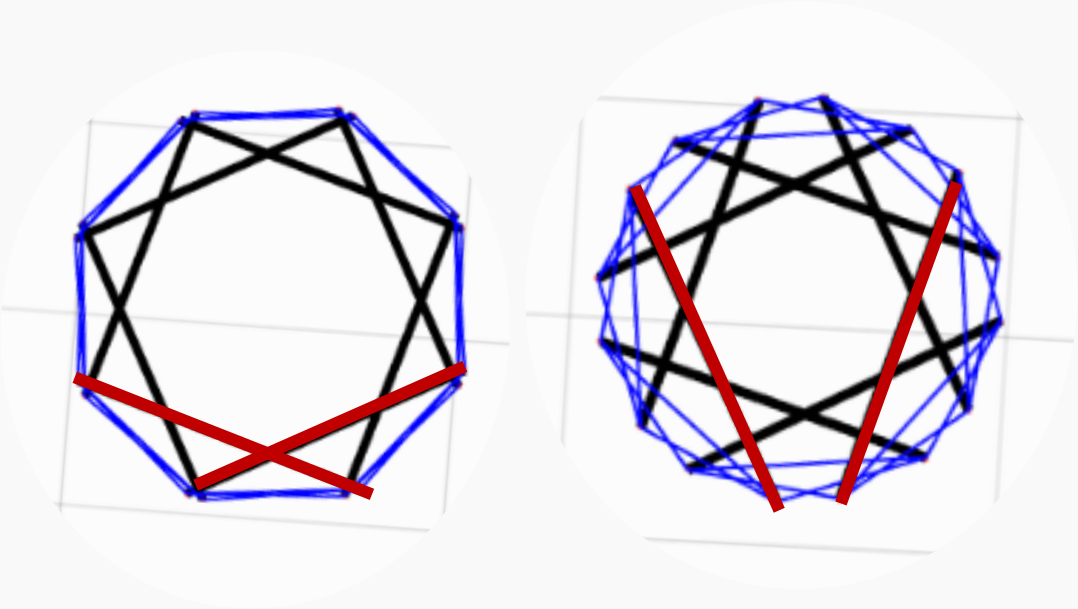


Figure 13. Landing strut orientations

- 8 strut prism base
- Strut count balanced between **radial stiffness** /mass and rolling efficiency/stroke length

Final Design Breakdown (Shear)

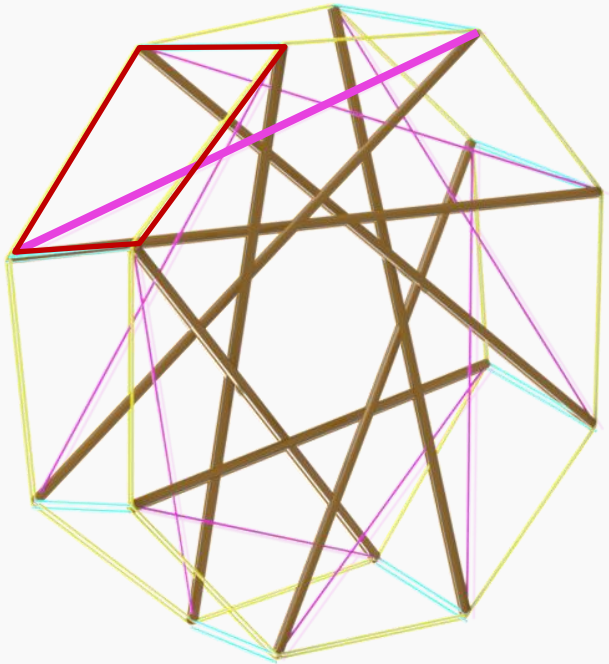


Figure 12. Prism face formed from tendons

- Extra tendon set to reinforce against shearing/twisting

Figure 13. Hopping Efficiency for v = -3.5m/s

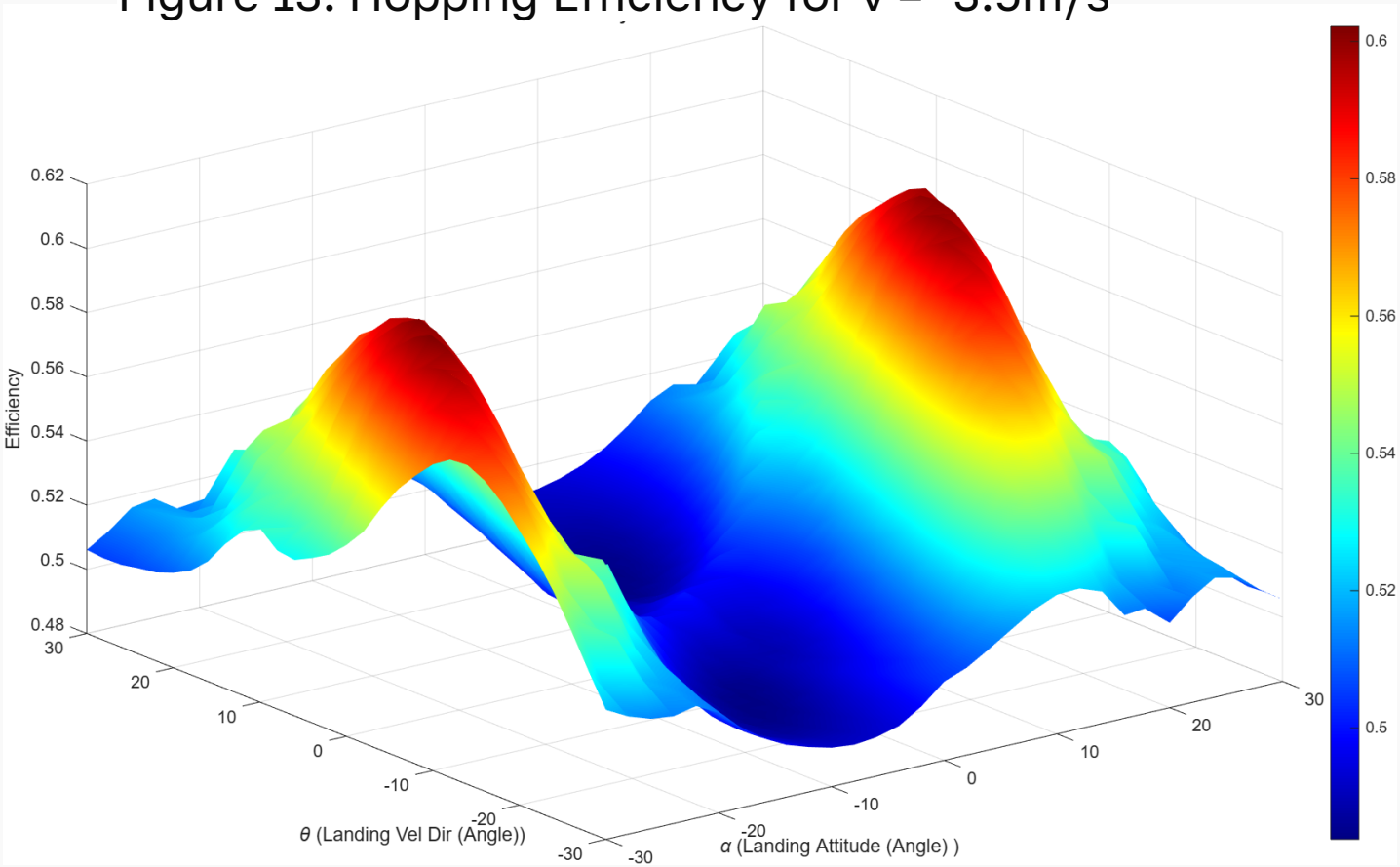
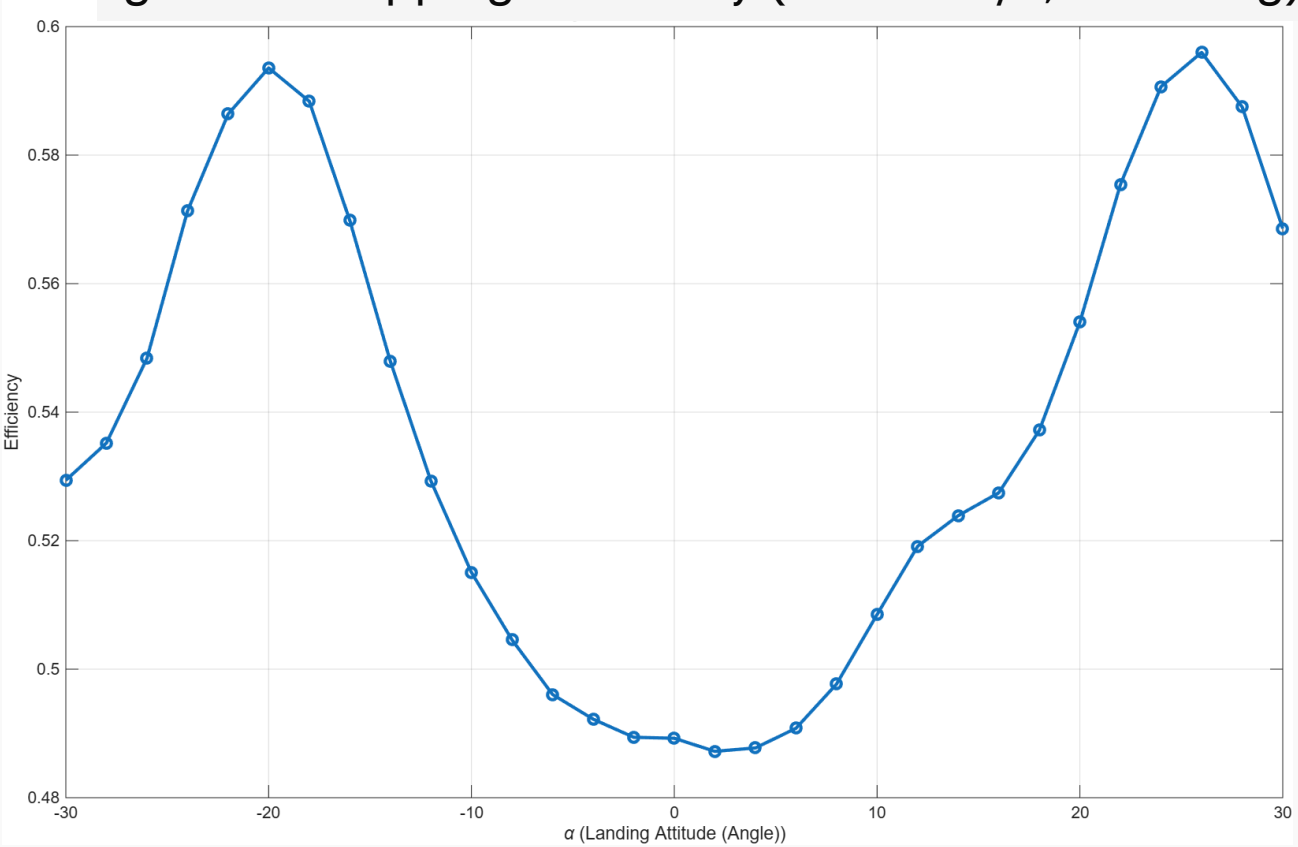


Figure 14. Hopping Efficiency (v = -3.5m/s, θ = 8 deg)



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Next Steps

Iterative Design and Validation

Construction and Physical Limitations

Figure 16.A. Tensegrity Wheel Rim

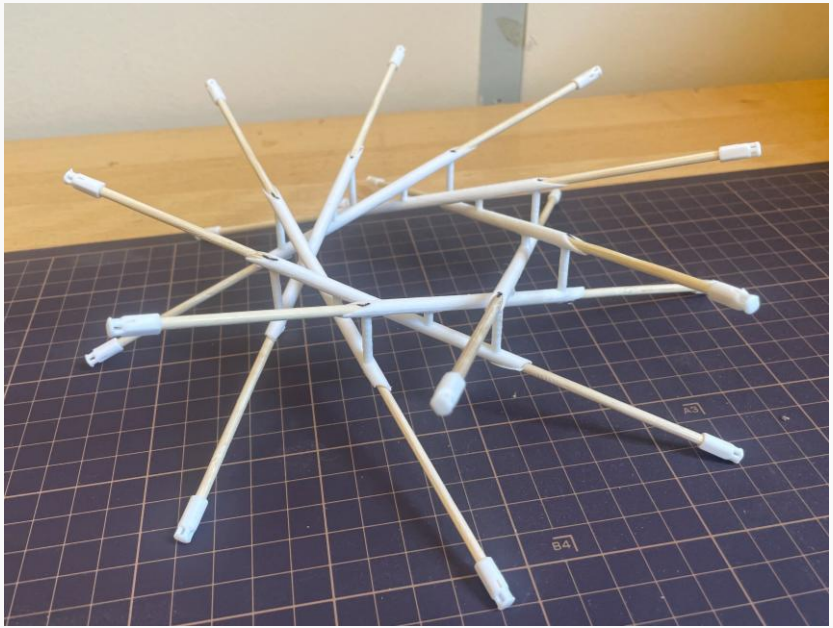
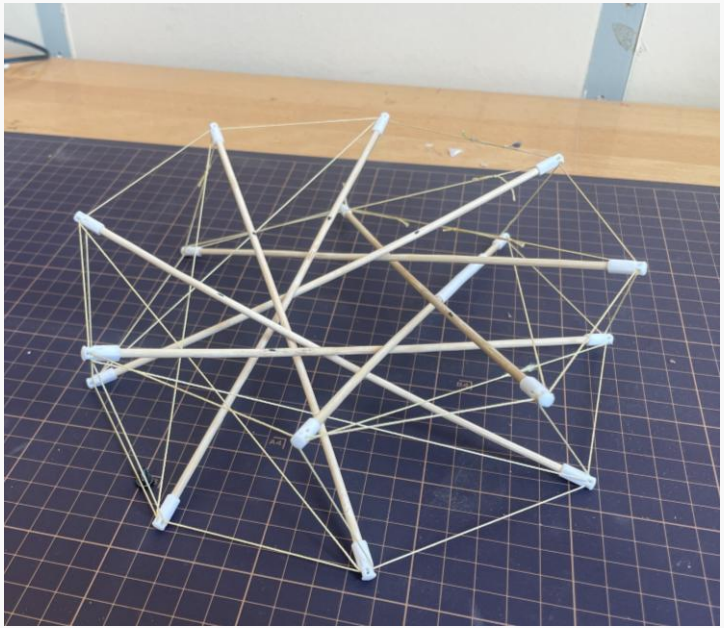


Figure 16.B. Built Final Wheel Rim



Iterative Design and Validation

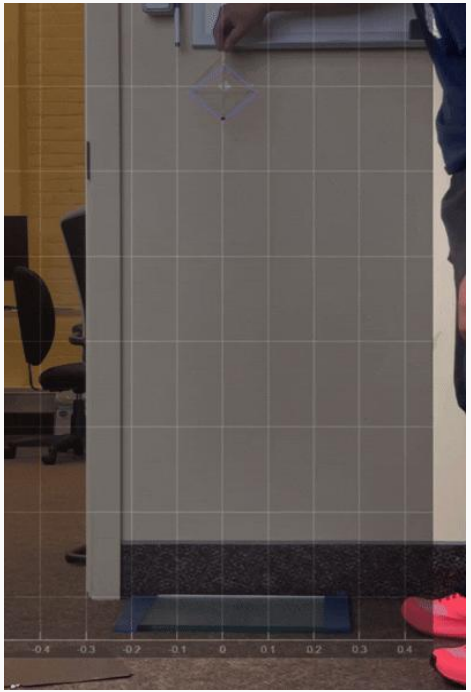


Figure 15. Physics engine validation

- Physical drop tests
- Better engine validation
- True building with quadcopter body

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[3] "Simple tensegrity structures," *Tensegriteit.nl*. [Online]. Available: http://www.tensegriteit.nl/e-simple.html. [Accessed: Aug. 24, 2026].

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[5] Wright, "167: R. Buckminster Fuller, Geodesic Tensegrity Sphere, 120 Strut, 4 Frequency Dome," *Wright Auctions*, Dec. 13, 2023. [Online]. Available: https://www.wright20.com/auctions/2023/12/design/167. [Accessed: Aug. 22, 2026].