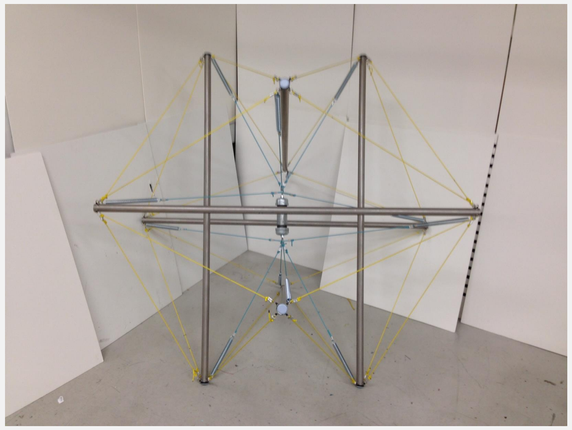
Validation of a Model for the Impact Landing of a Tensegrity Landing System

Summary: In this project impact tests were performed on a spherical tensegrity structure with an instrumented payload to determine the accuracy of current simulations for impact events.

Tensegrity Background

- Network of struts suspended in cables
- All parts in either pure tension or compression
- Axial stress state creates high strength to weight ratio
- Chosen structure: Six Strut Icosahedron
- Icosahedron has adequate central void for payload

Prototype Structure



Six bar icosahedron structure with payload

Prototype Structure Components

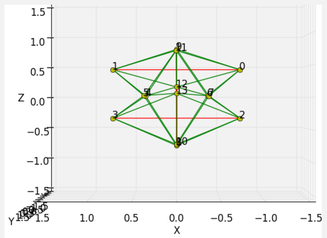
- Paracord for outer springs
- Inner springs attached at structure nodes
- Aluminum struts

Prototype Structure Parameters

Strut Length	1.5 m
Strut Mass	1.14 kg
Payload Length	0.26 m
Payload Mass	1.2 kg
Spring Rate	1051 N/m *(6 lb/in)*
Spring Pretension	17.8 N
Spring Length	0.15 m
Spring Mass	0.12 kg

Simulation

- Based on Euler-Lagrange equations
- Floor stiffness modelled as concrete
- Massless springs
- Spring preload applied with artificial extension of springs in model
- Output forces and payload state



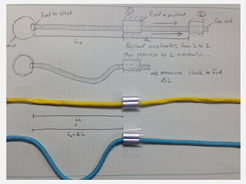
Visualization of structure in simulator

Experimental Set up

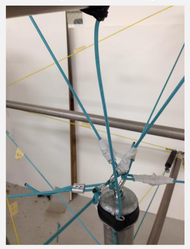
- Drop heights at 1, 1.5, and 2 meters
- Acceleration acquired at 512 Hz
- Deflection acquired via sliding crimp method
- Dropped onto two vertical struts (worst case configuration)

Payload with accelerometer

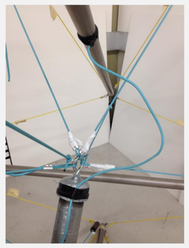
Sliding Crimp Method



Concept description



Pre-drop position

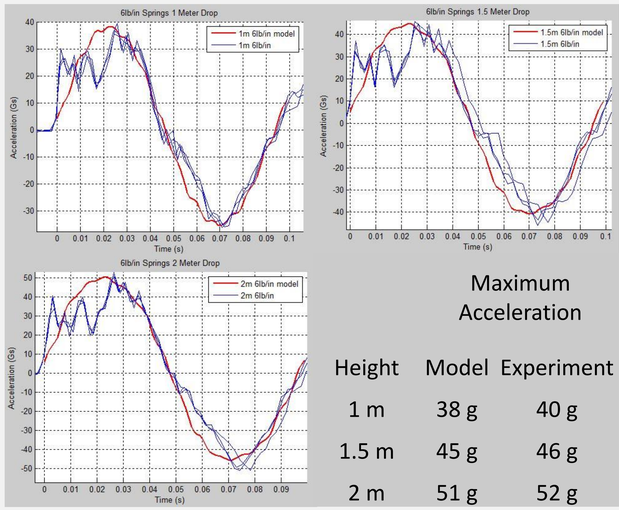


Post-drop position

Deflection Data

Height	Model	Experimental
1 m	5.2 cm	13.2 cm
1.5 m	6.4 cm	14.7 cm
2 m	7.5 cm	15.4 cm

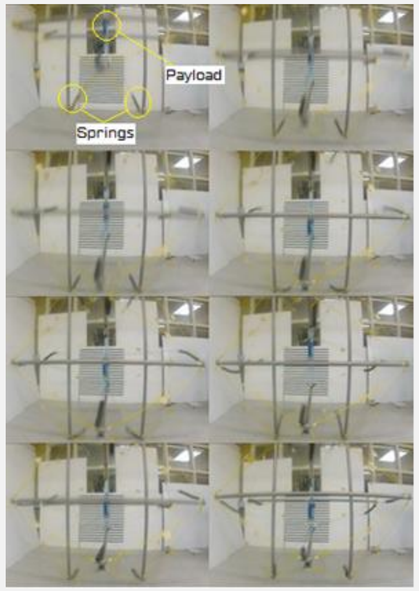
Acceleration Data



Maximum Acceleration

Height	Model	Experiment
1 m	38 g	40 g
1.5 m	45 g	46 g
2 m	51 g	52 g

Impact Sequence



Experimental Observations

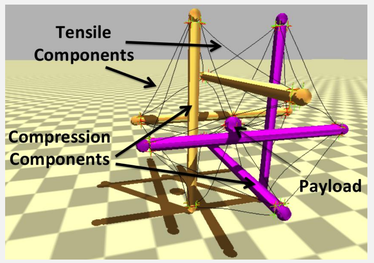
- Significant transverse oscillation of springs
- Bottom springs contact ground
- Forces on inner cables inside expected range

Discussion

- Experimental acceleration results repeatable
- Model acceleration profile matches experimental results
- Springs likely need to be modelled with mass
- Sub-oscillations likely arise from transverse motion of springs
- Investigation of simulation indicated modelling springs with mass necessary for deflection to be consistent with experiments

Future Work

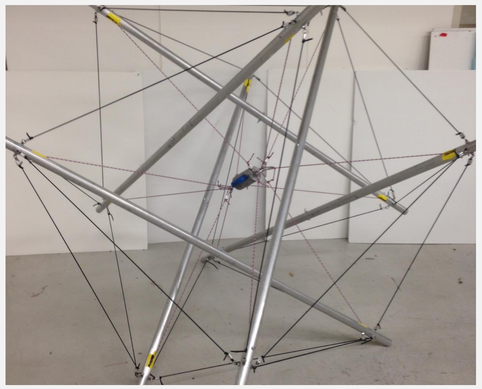
- Compare experimental results to output from NASA Tensegrity Robotics Toolkit (NTRT)
- Model springs with mass
- Drop test with internal springs
- Measure forces during impact
- Test other impact orientations



NTRT simulation of structure with payload

Authors:

Kyle Morse[1]
(mors9075@vandals.uidaho.edu)
Sophie Milam[1]
Alex Ackerman[1]
Nick Clyde[1]
Will Hoffman[1]
Brenden Kaschmitter[1]
Mary Yovanoff[1]
Vytas Sunspiral[2]
Dr. David Atkinson[1,3]
[1] *University of Idaho*
[2] *NASA Ames Research Center*
[3] *Jet Propulsion Laboratory*



University of Idaho
College of Engineering

IPPW-11 2014
Abstract #8056

http://mindworks.shoutwiki.com/wiki/Tensegrity_payload_protection