



Spacecraft Inspired by Origami

Space Engineering Seminar

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Quick quiz...



What is the most times a pieces of paper can be folded?

*Answer: Old myth said not more than **7 times***

But..

*From Mythbusters team, they proved that we can fold paper **11 or 12 times** using very specialized sheets of paper*

Outlines

- History behind Origami
- How origami in space?
- Benefits and challenges
- Research related to use origami in space
- Conclusion
- Reference

History behind Origami

- Japanese word, *ori* means '**folding**' and *kami* (change to *gami* due to *rendaku*/sequential voicing) means '**paper**'
- In **Japan**, practiced since Edo period (1603-1867) for **traditional art design**
- In **China**, practiced since Sung Dynasty (905-1125 CE) for **traditional funerals**
- In **Europe**, practiced since 17th century for **napkin folding**
- Art of paper folding using origami paper and tools



Source: <https://en.wikipedia.org/wiki/Origami>

History behind Origami



In China, burning yuanbao



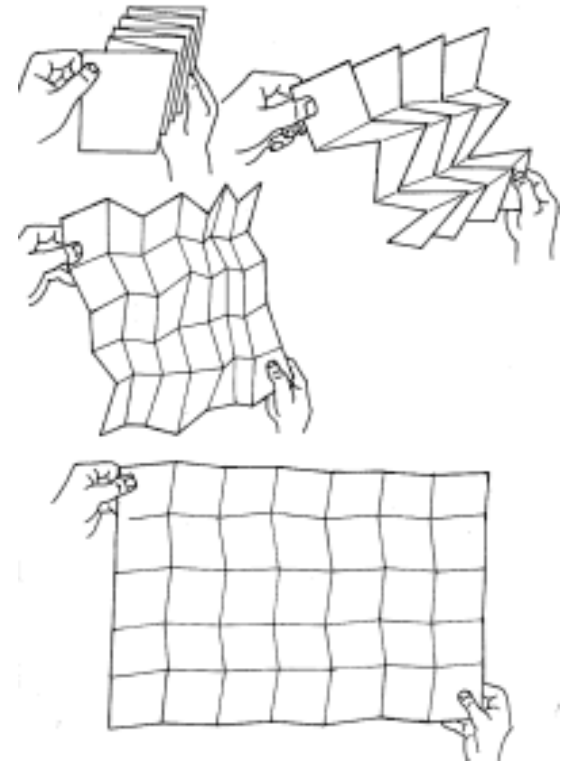
In Japan, origami crane



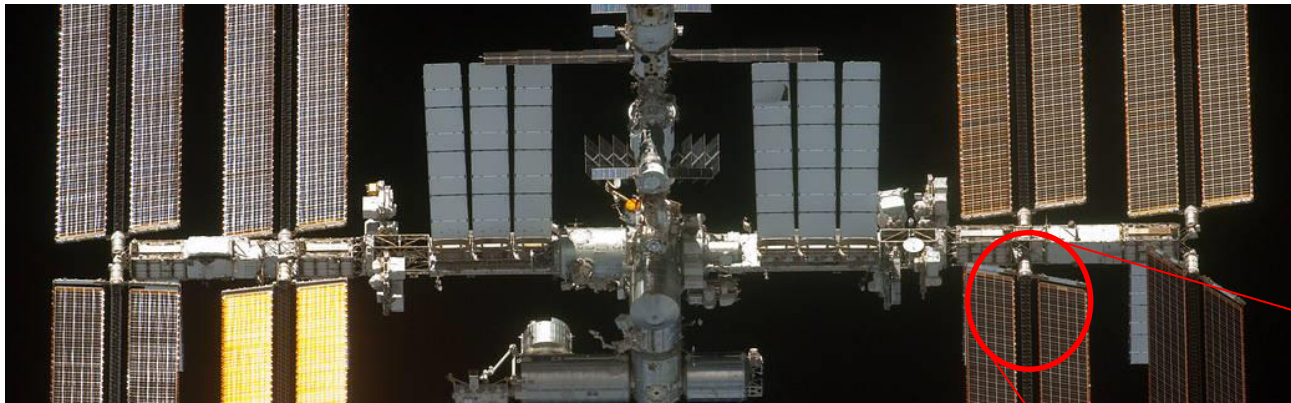
In Europe, napkin folding

How origami in space?

- To reduce the cost of launching satellites, need to reduce the weight and size
- Design methods called computational origami
- Using mathematical tool
- Well known origami is Miura-ori folds
 - From the man who invented it, Koryo Miura
 - Popular for deployment solar panels
 - The fold described as shape-memory origami



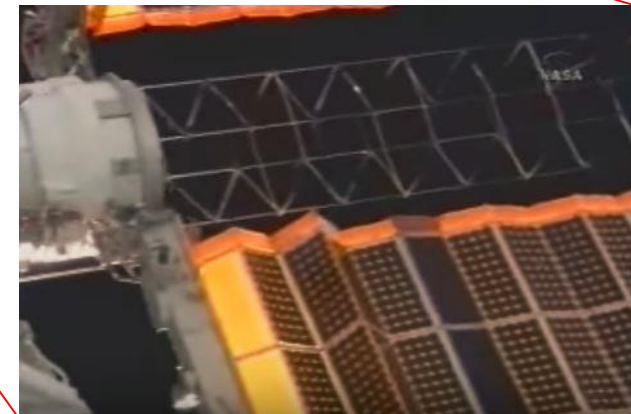
Example using origami in satellite



Source: NASA

1. Solar arrays of International Space Station (ISS)

- Technology called *ROSA*; roll out solar array
- Make it a *flexible* solar arrays
- Increase the *power*
- Without increasing the *mass*

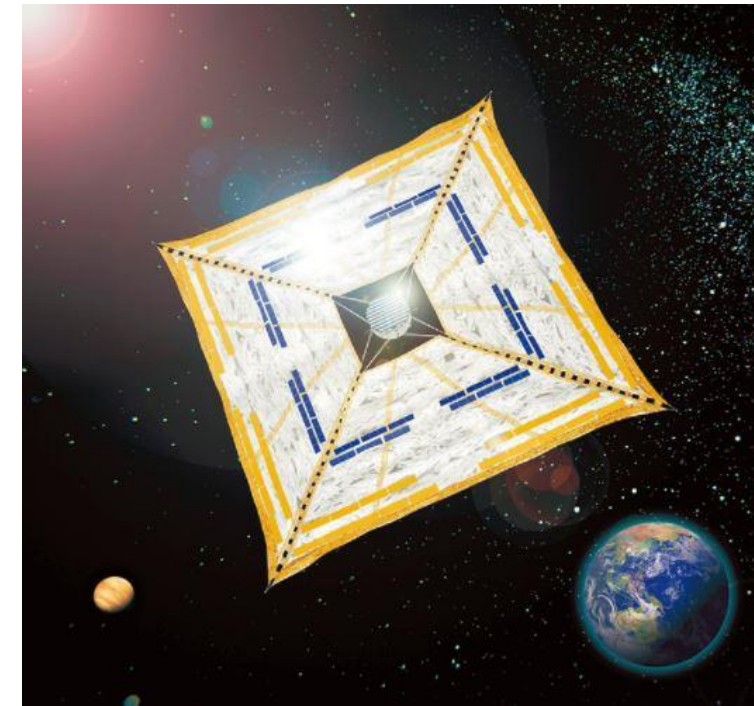


<https://www.youtube.com/watch?v=XRXbi3sQKWc>

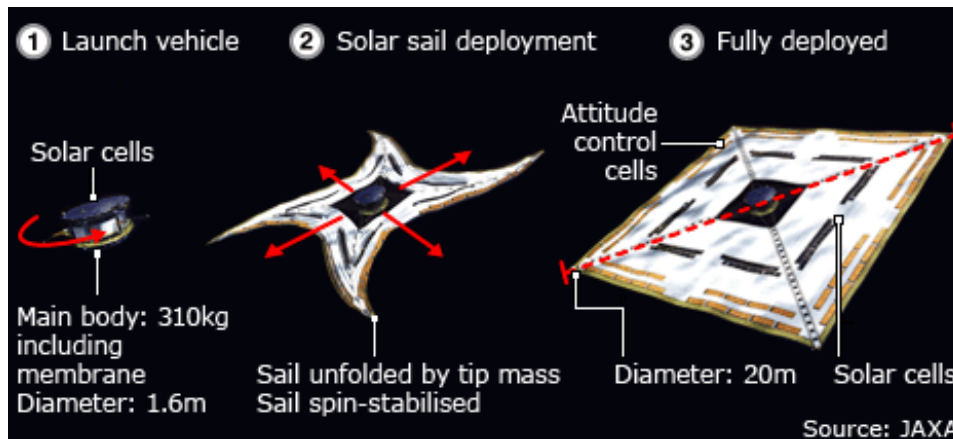
Example using origami in satellite

2. Small Power Solar Sail IKAROS

- Technology called Membrane Deployment Mechanism
- 2 stages of deployment:
- First stage deployment (Static)
- Second stage deployment (Dynamic)
- From 1.6m to 20m (diagonal) of full deployed



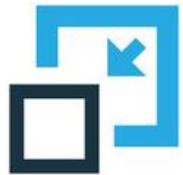
Source: JAXA



Benefits and Challenges

Benefits

- Less size
- Less weight
- Less cost
- Increase the output functionality



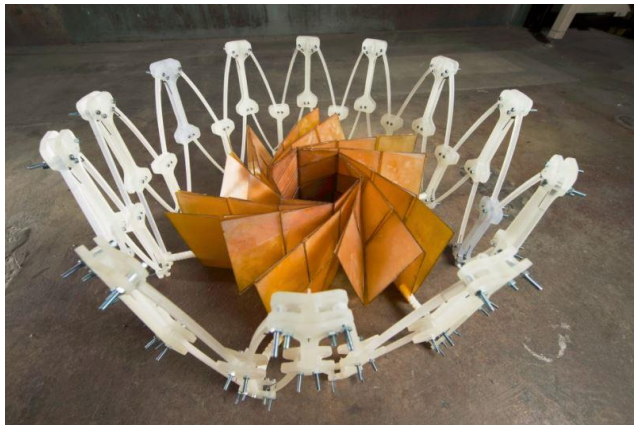
Challenges

- Complex design
- High risk
- Creativity

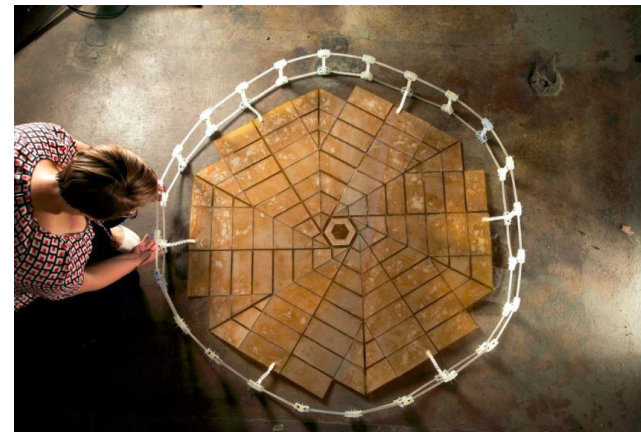
Research related origami in space

1. New research of deployment silicon solar panel in small satellite

- Mechanical Engineering, Brigham Young University (BYU)
- Shannon Zirbel and her team under the project of unfolds of solar panel arrays
- Unfold 10 times its stored size
- Size about 1U Cubesat



Source: BYU



2. The new research of “smart” radiator

- New type of temperature-regulating radiator for Cubesats
- Collaboration of NASA scientist and professor from Brigham Young University and University of Maryland
- New coating technique for the radiator, vanadium-oxide with thin films of silver and titanium
- The goal is to lower the transition temperature



*Picture of Vivek Dwivendi
Source: NASA*

What next using origami structured in space?

Maybe antenna origami??

Conclusion

- New technology can be created by combining art, mathematical tools, and engineering application
- The main goal of reducing the cost and size of building satellite can be achieved using origami structure technology
- Let be a creative engineer!

Thank you for your attention.

- <http://web-japan.org/niponica/niponica18/en/feature/feature05.html>
- https://www.surrey.ac.uk/ssc/research/space_vehicle_control/cubesail/science_and_tech/folding/
- <https://www.space.com/27485-origami-space-solar-panels-video.html>
- <https://naturalorigami.wordpress.com/2016/07/18/the-miura-ori-fold/>
- <https://www.nasa.gov/feature/goddard/2017/nasa-s-new-shape-shifting-radiator-inspired-by-origami>
- <https://en.wikipedia.org/wiki/Origami>