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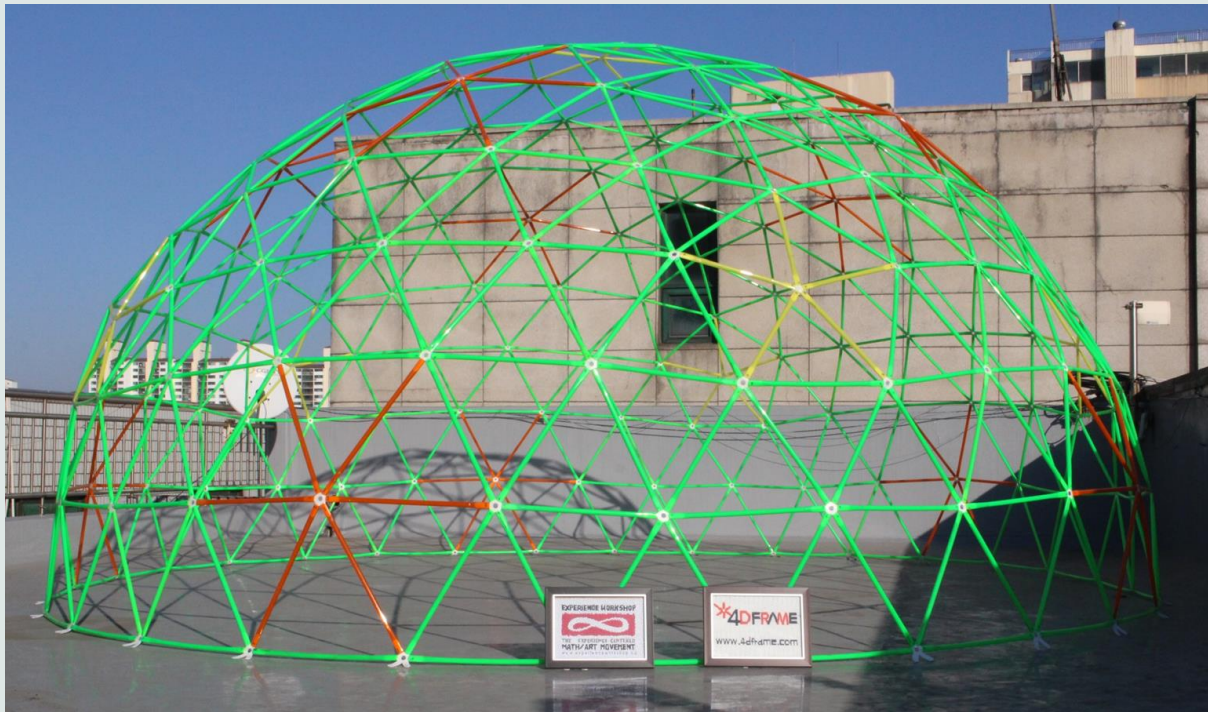
# Experience Workshop's STEAM Learning Material

Build a giant geodesic dome with 4D Frame



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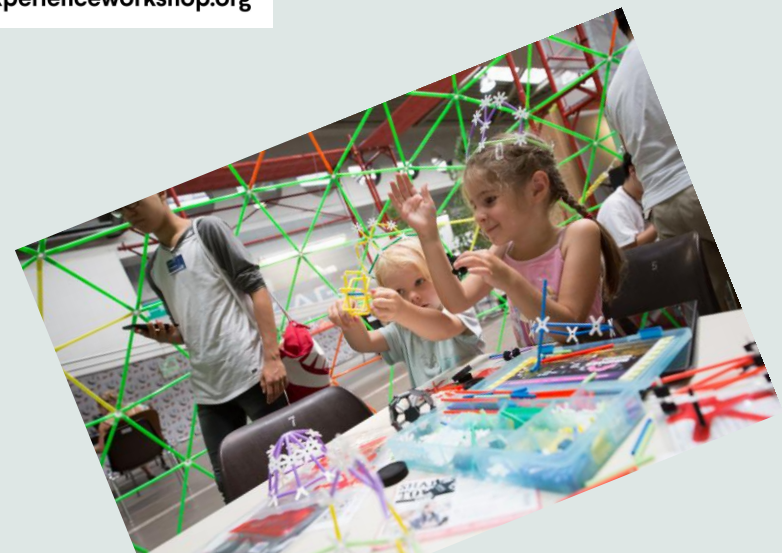
# What is STEAM education?




- The **Finnish National Core Curriculum** makes recommendations to teachers and schools about the development of *student-centered*, *multidisciplinary / phenomenon-based learning* programs and collaborative teaching.

- **STEAM** provides a reasonable basis to complete this requirement, as it means the *multidisciplinary or transdisciplinary integration of* **S**cience-, **T**echnology-, **E**ngineering-, **A**rts- and **M**athematics learning about various topics.

- **STEAM** is based on the collaboration between the teachers.

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# STEAM EDUCATION

## What is STEAM Education?

STEAM stands for Science, Technology, Engineering, the Arts, and Mathematics, referring to an integrated approach to learning.

Through project-based, creative methods, STEAM Learning aims to foster problem-solving, collaboration, integrative thinking.

STEAM can boost students' engagement, motivation and their joy of learning.

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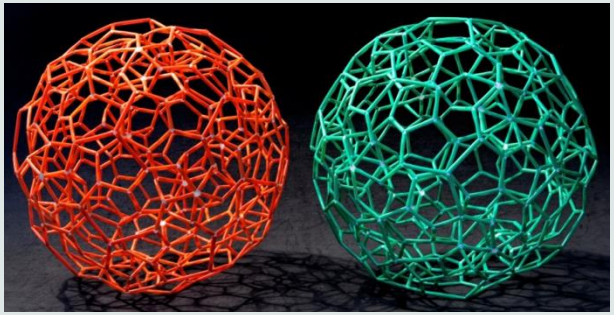
# Introduction to hands-on modelling with 4D Frame

free imagination and infinite creativity



The 4Dframe educational modelling kit was developed by **Ho-Gul Park**, a Korean engineer and model maker originally inspired by classical, Korean architecture. 4Dframe's concept is based upon the structural analysis of **construction techniques of Korea's traditional, wooden buildings**.

The 4Dframe set consists of a small number of elegantly structured, simple module pieces. The wealth of structural variability offered by this versatile device renders it an excellent educational tool for conceptualizing, modelling, or analyzing topics relevant to all STEAM fields, such as **science, technology, engineering, arts, and mathematics**.

Due to its numerous advantages, 4Dframe is perfectly adaptable to inquiry-based, playful learning and to experience-oriented pedagogical approaches or to phenomenon-based learning.

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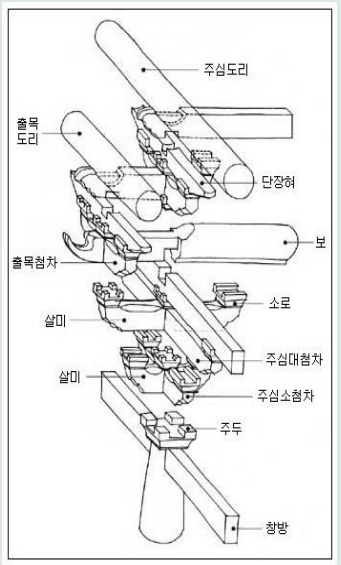
# Introduction to hands-on modelling with 4D Frame

4D Frame has proved to be an **appropriate tool for developing various skills in the transdisciplinary framework of STEAM learning**.

4D Frame toolkits are **available from the webshop** [www.experienceworkshop.org/shop](www.experienceworkshop.org/shop)

traditional Korean wooden palace




principles of construction

4D Frame tube

4D Frame connector

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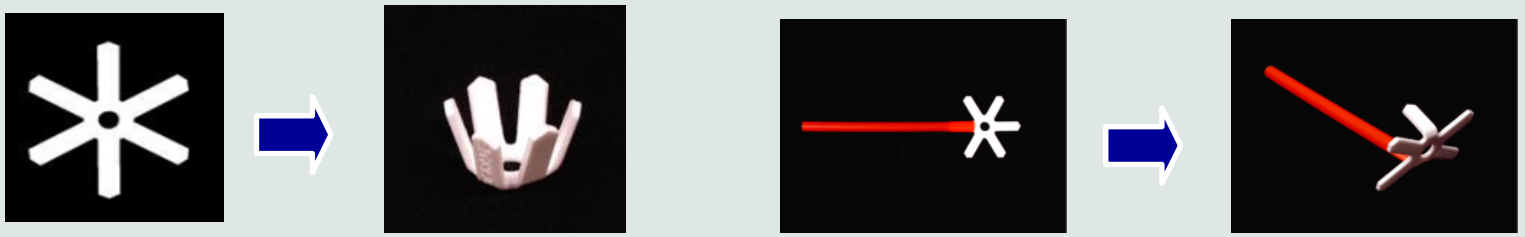
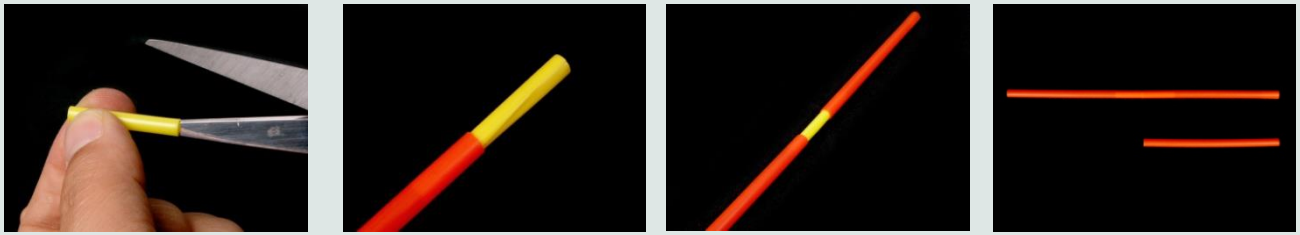
# Introduction to hands-on modelling with 4D Frame



bend, cut & connect!



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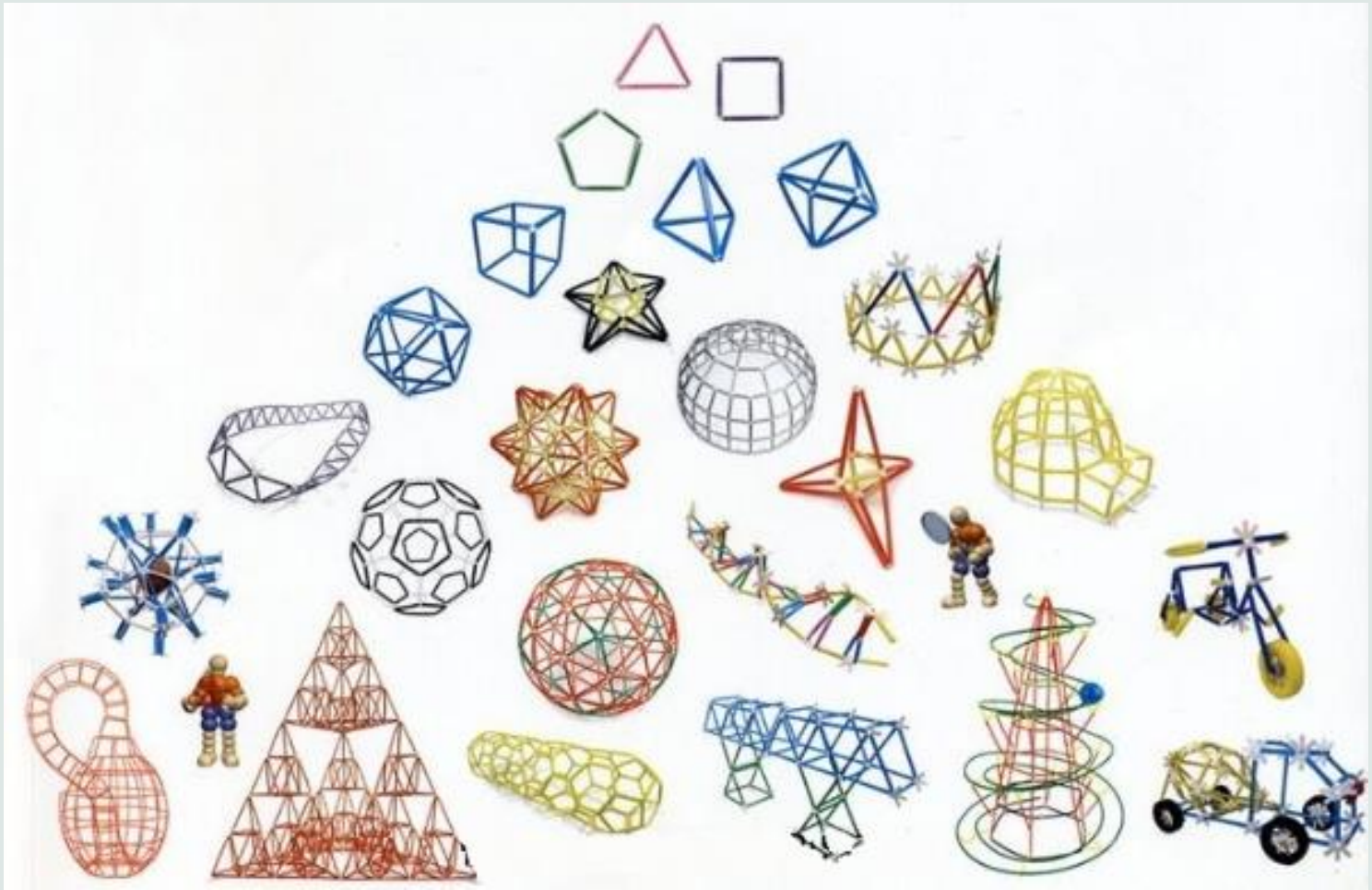
# Introduction to hands-on modelling with 4D Frame



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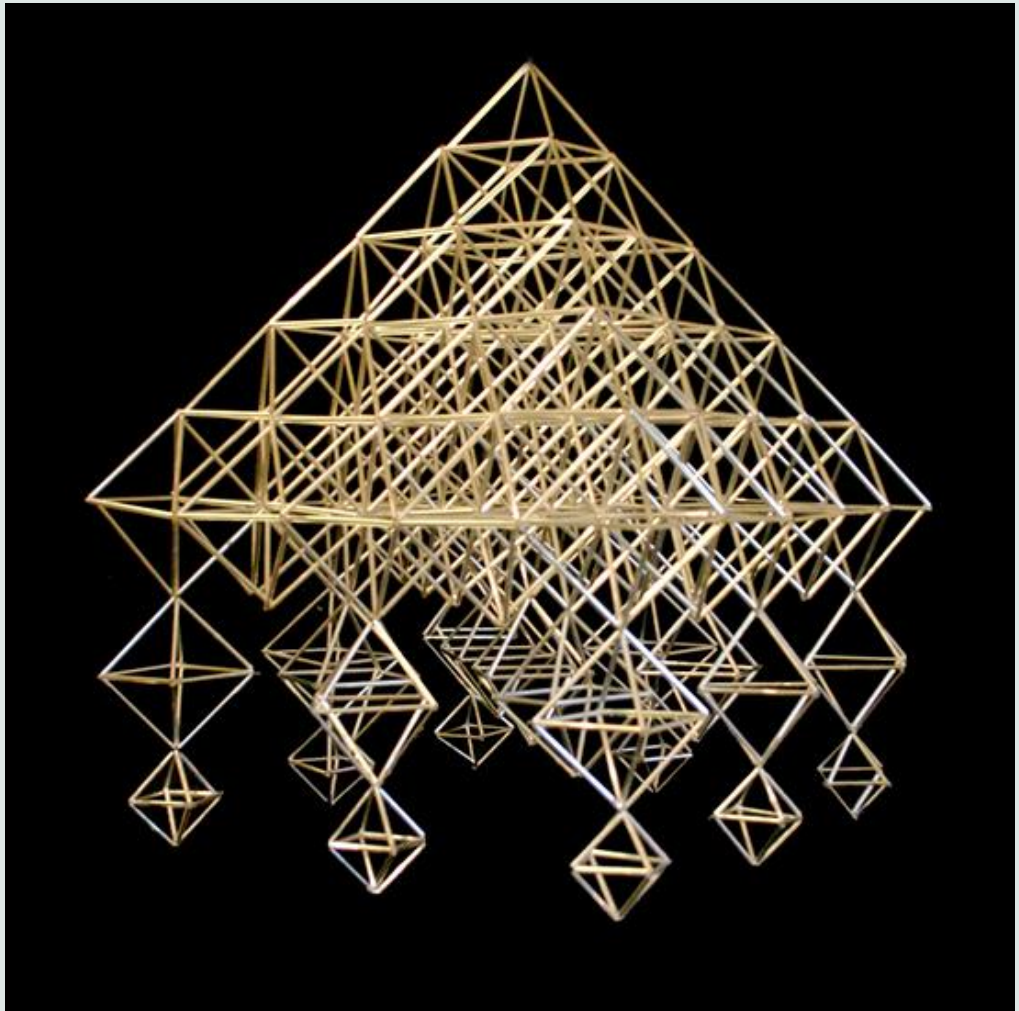
# Introduction to hands-on modelling with 4D Frame

The traditional Nordic Christmas decoration: the himmeli



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# Introduction to hands-on modelling with 4D Frame

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# Introduction to hands-on modelling with 4D Frame

Tubes

Connectors

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The world's largest ice dome, built in Finland in 2014. More information: http://www.structuralice.com/pykrete-dome.html

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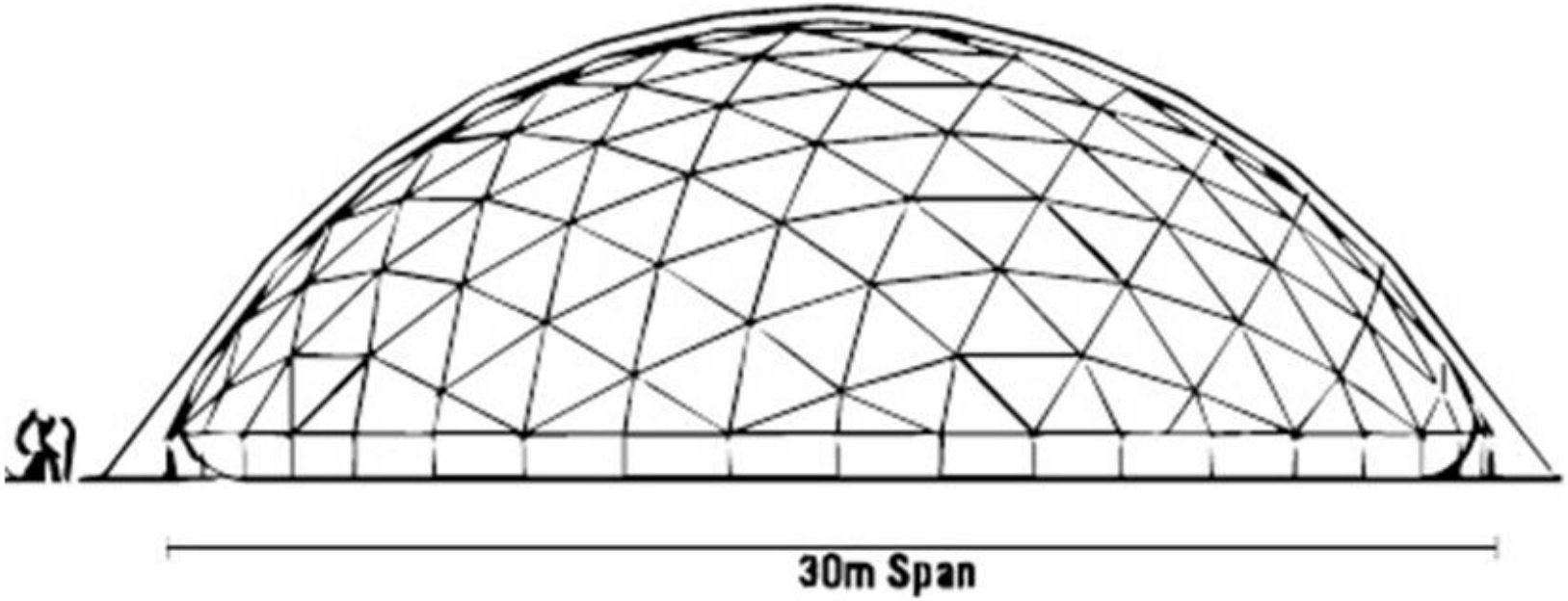

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# Other examples

Leonardo da Vinci’s dome structure,
reconstructed by Rinus Roelofs

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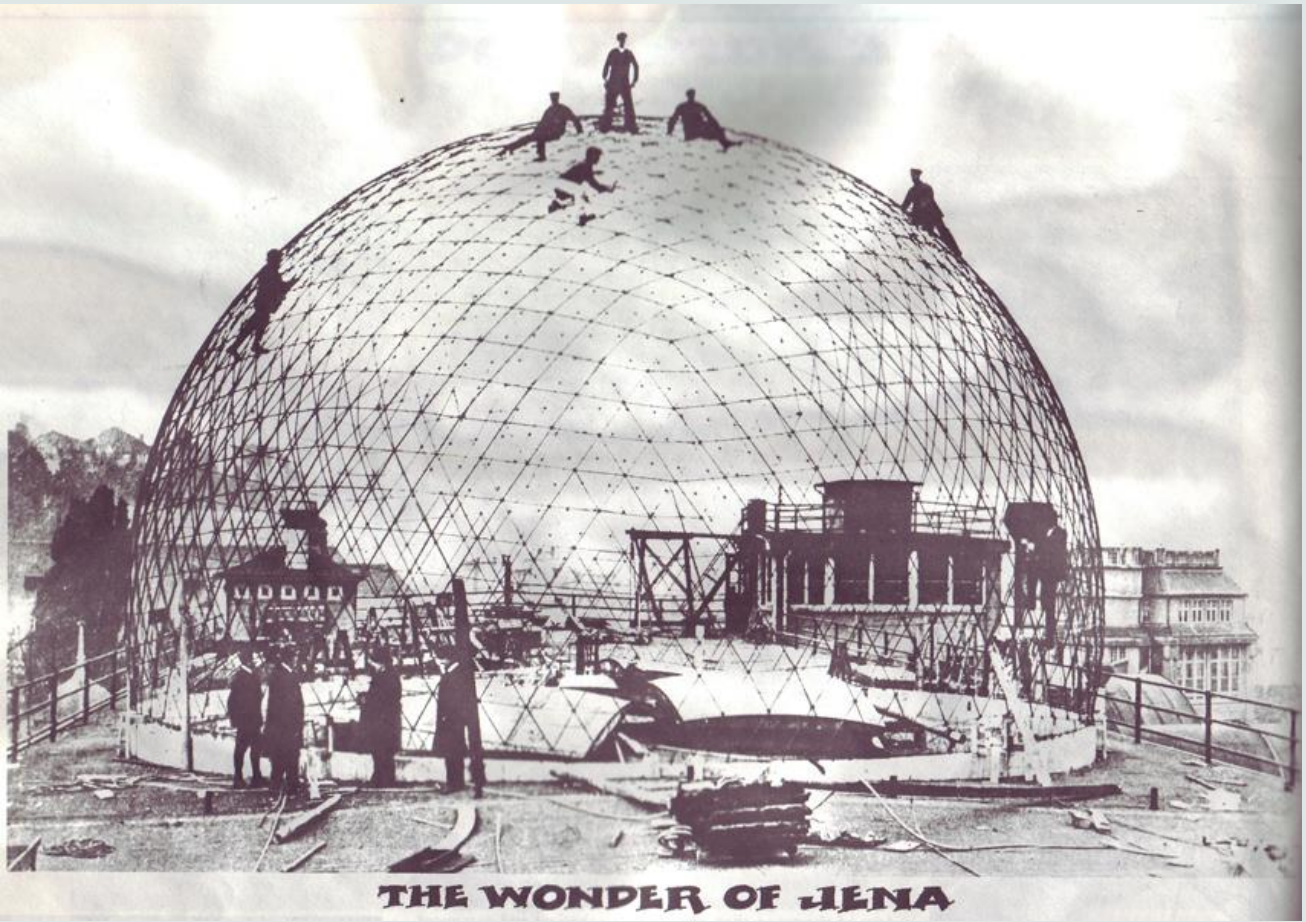
# Other examples




The honour of being the first to design a geodesic structure goes to **Dr. Walter Bauersfeld**, chief designer at the Carl Zeiss Optical Works in Jena in 1922 at the time called **'The Wonder of Jena'**.

This structure formed **the shell of the Zeiss Planetarium**. 25 more were built including one in Chicago in 1930.

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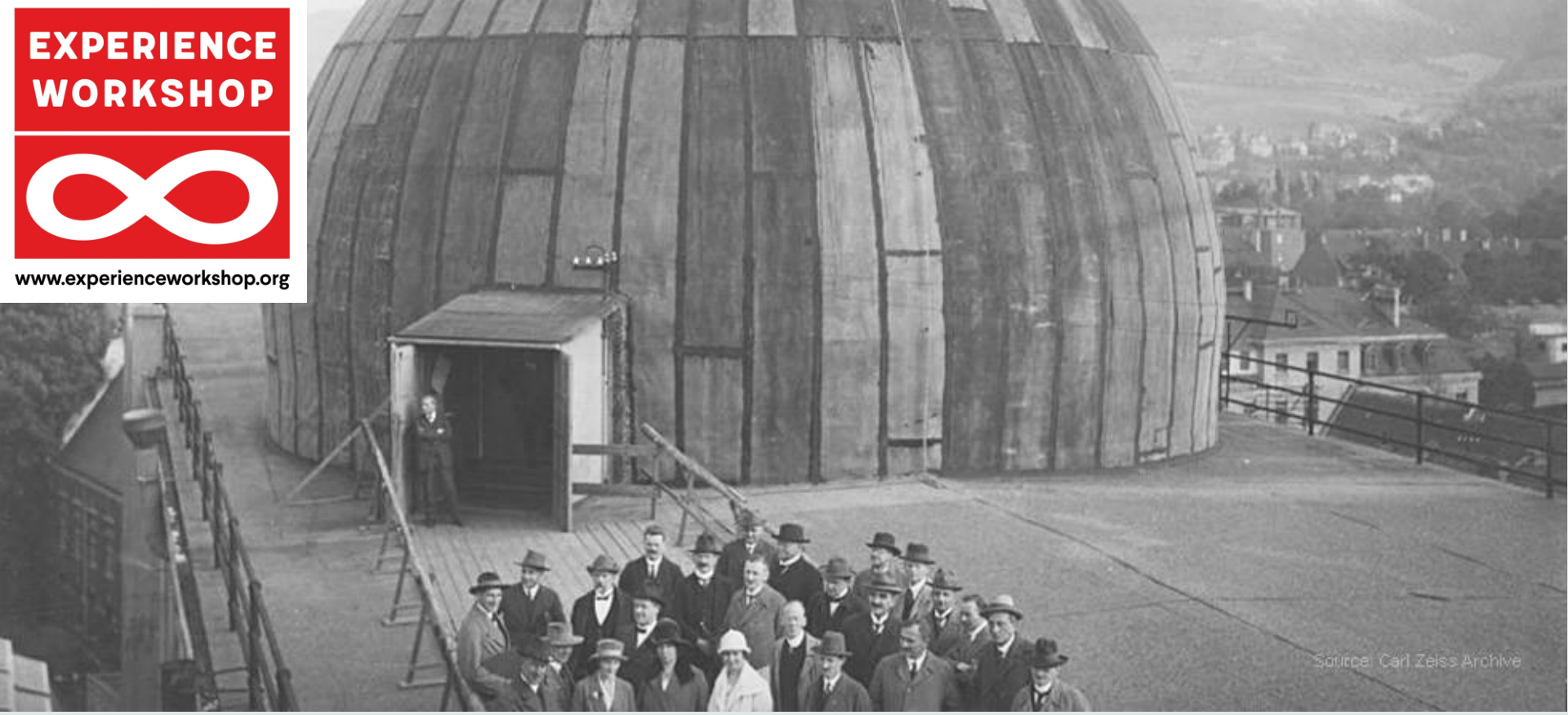


**Did you know…**

**…that the world's first planetarium was erected on the roof of the ZEISS Factory?**

The first artificial night sky was shown in Jena in the summer of 1923. 10 years earlier, Heidelberg astronomer Max Wolf suggested the idea of a planetarium to Oskar von Miller, founder of the Deutsches Museum in Munich. He, in turn, approached Carl Zeiss Jena. After an interruption caused by World War I and a range of design issues, **Walther Bauersfeld, chief engineer at ZEISS**, developed Model I, which was tested in a specially built, 16-meter dome on the roof of the factory in Jena. Beginning in August 1924, presentations were also offered to the public. The very first projector was in service at the Deutsches Museum from 1925 to 1960, and it continues to be on display up to the present day.

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Some decades later **Richard Buckminster "Bucky" Fuller**, an American architect, engineer and visionary thinker, popularized the special structure of the geodesic dome throughout the world.

**A geodesic dome was constructed to cover the American pavilion for the World Fair in Montreal in 1967** according to his plans. The building can still be seen.

**Its diameter is 80m and it is 65m high.**

**Where does the word "geodesic" come from?**

The Greek word *geodos* means Earth.

"Geodesic" means *Earth-like.*

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"Spaceship Earth," the AT&T Pavilion at Epcot in Disney World, Florida.

The People's Meeting Dome by Tejlgaard & Jepsen, Denmark

Nature House, a gorgeous geodesic dome home on the Sandhornøya island of northern Norway.

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A geodesic dome is a spherical or partial-spherical shell structure or lattice shell based on a network of great circles (geodesics) on the surface of a sphere.

The geodesics intersect to form triangular elements that have local triangular
rigidity and also distribute the stress across the structure.

[en.wikipedia.org/wiki/Geodesic_dome](en.wikipedia.org/wiki/Geodesic_dome)

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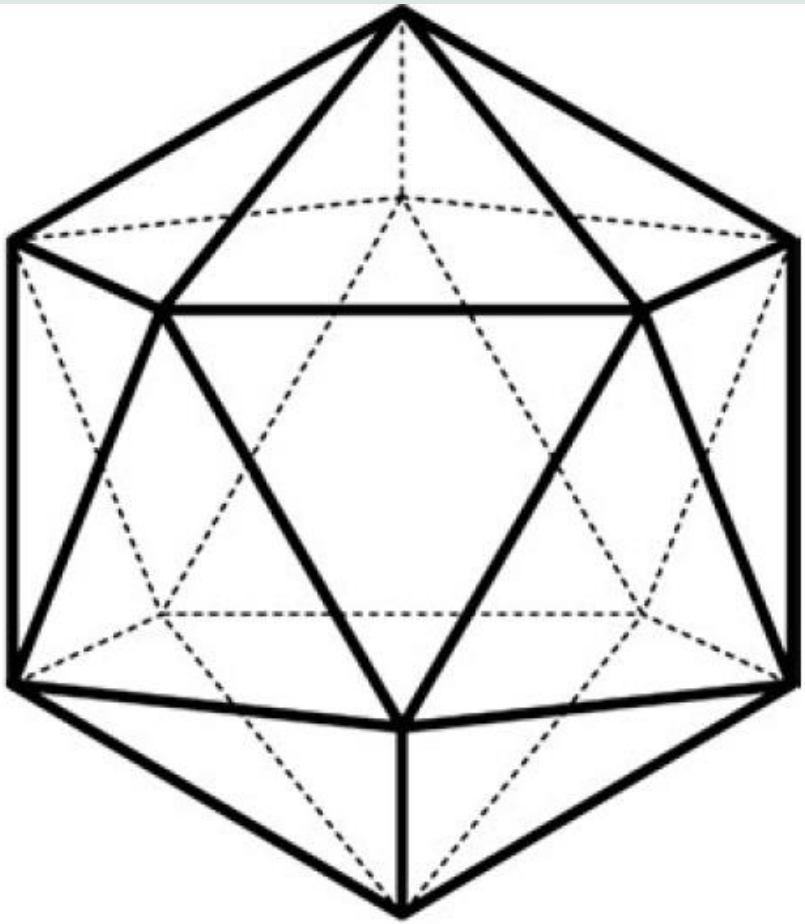

The construction of Fuller's geodesic dome is based on the geometric shape called **icosahedron.**

If you take a closer look at the figure, you can see that each edge of the icosahedron is of the same length, and triangles of equal size are components of the structure.

The icosahedron is composed of 20 identical equilateral triangles, and a sphere can be circumscribed around the structure.

Features of the geodesic dome's edges are denoted by the frequency number.

Because of the equal length of edges, the frequency number of a geodesic dome generated from a regular icosahedron is 1.

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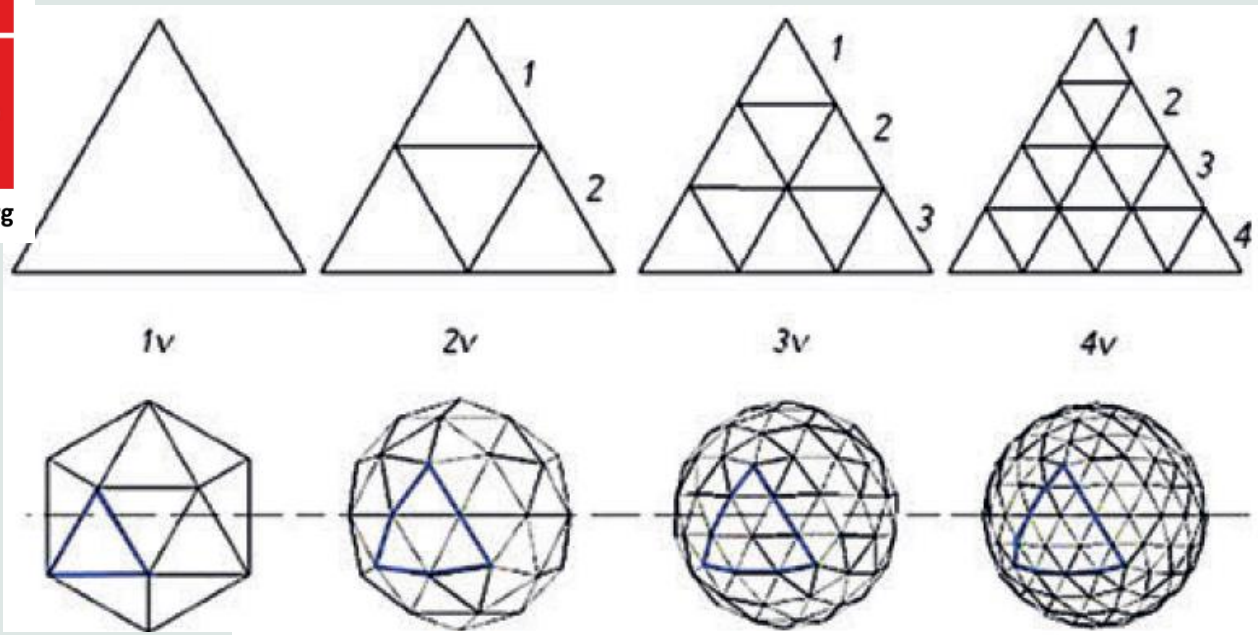


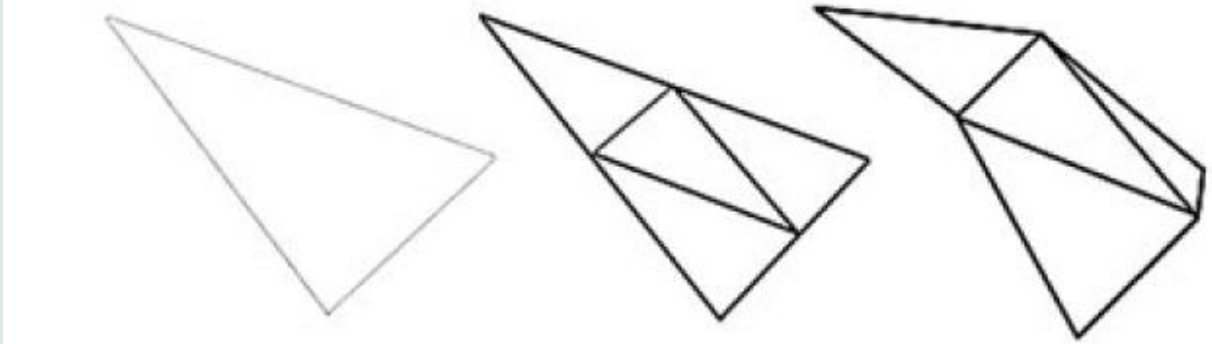

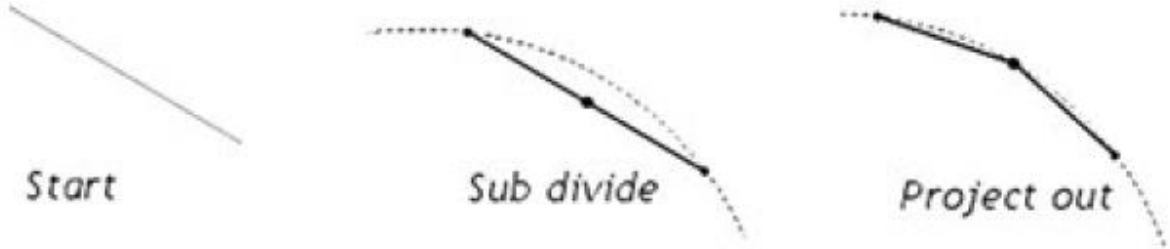

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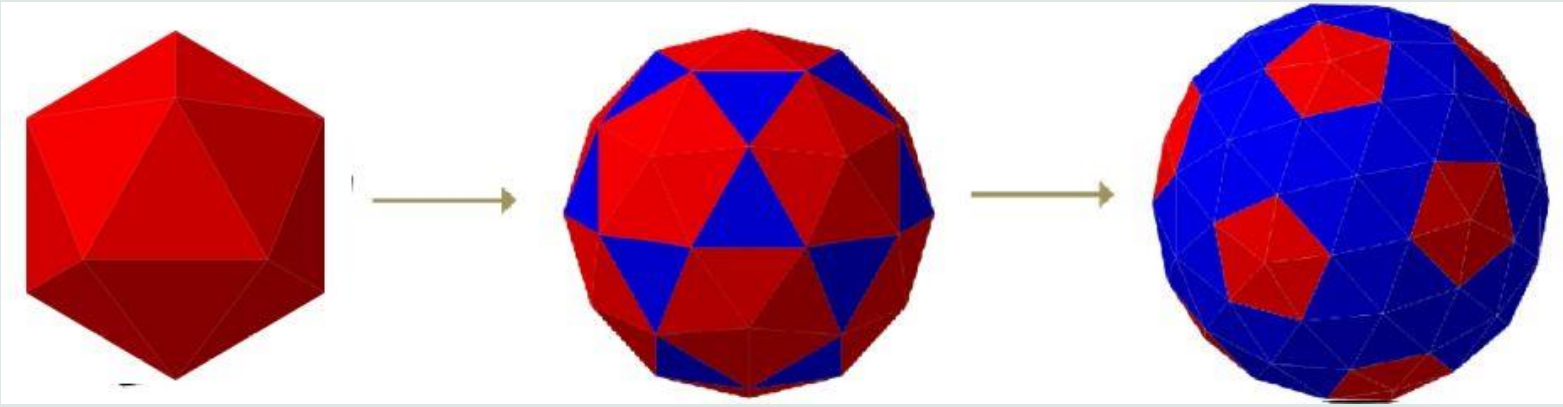

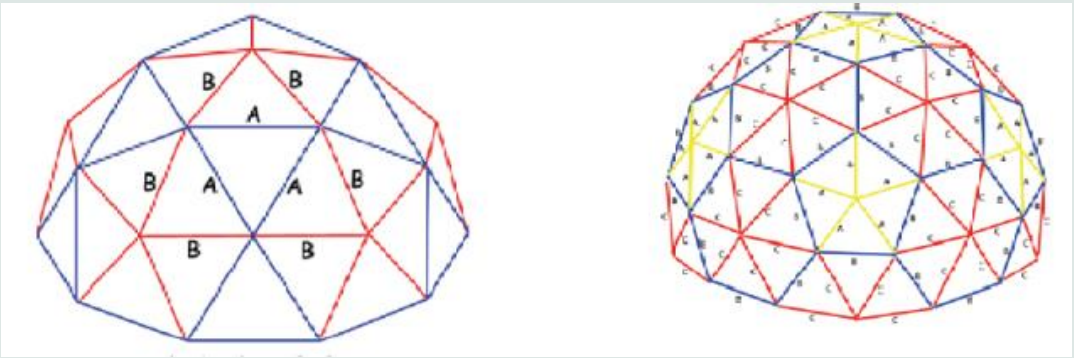

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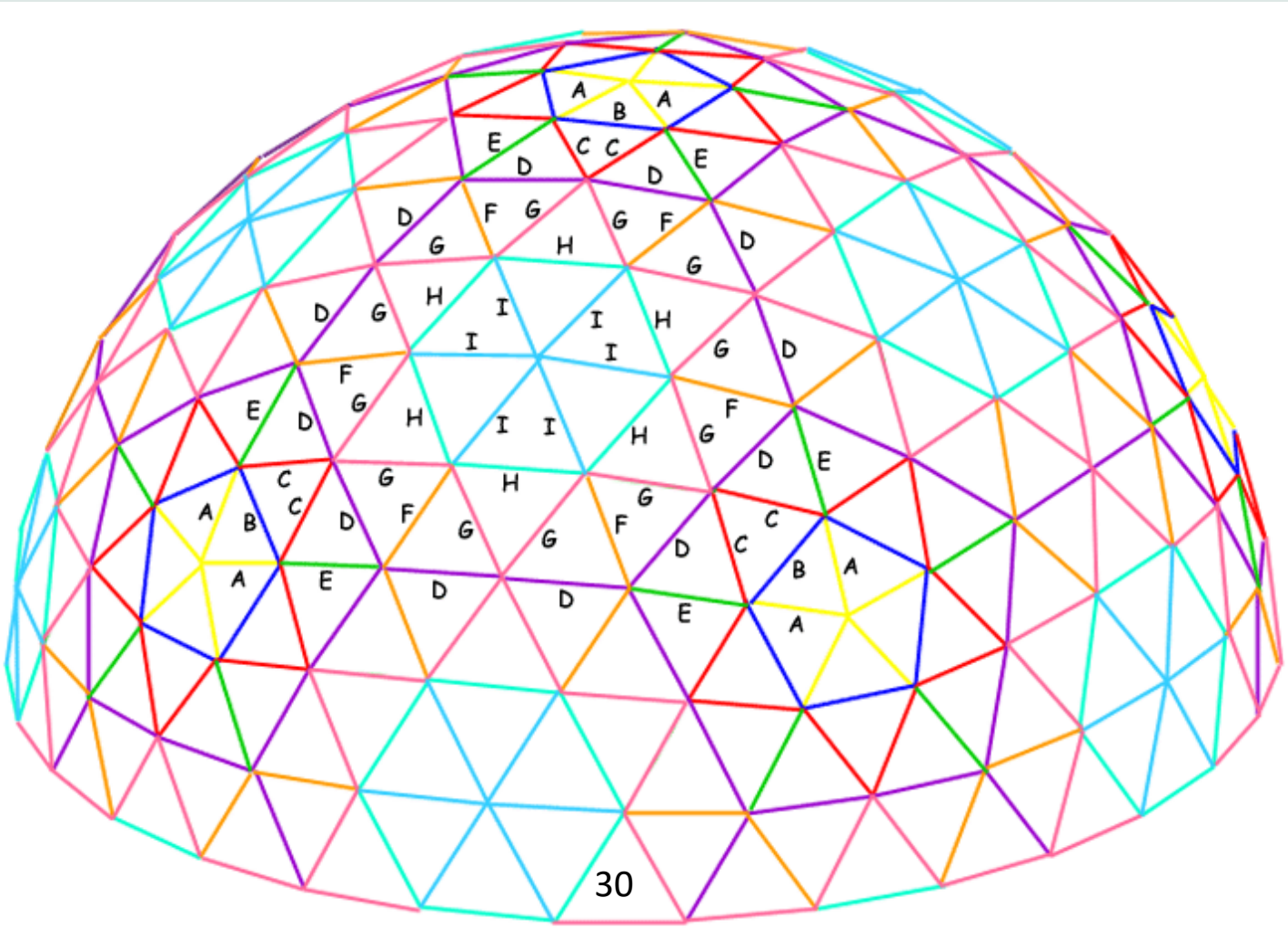
| Components | Length of each tube | | Needed pieces |
|---|---|---|---|
| | before | after | |
| A | 53 | 42 | 30 |
| B | 60 | 49 | 30 |
| C | | 47 | 60 |
| D | | 52 | 90 |
| E | | 48 | 30 |
| F | | 51 | 60 |
| G | | 53 | 130 |
| H | | 55 | 65 |
| I | 60 | 56 | 60 |
| 5-way connectors | | | 12 |
| 6-way connectors | | | 380 |



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A : 42cm 30pcs
B : 49cm 30pcs
C : 47cm 60pcs
D : 52cm 90pcs

E : 48cm 30pcs
F : 51cm 60pcs
G : 53cm 130pcs
H : 56cm 60pcs

I : 56cm 60pcs
5-way connectors : 12pcs
6-way connectors : 380pcs

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# Some mathematical explanations on constructing the geodesic dome

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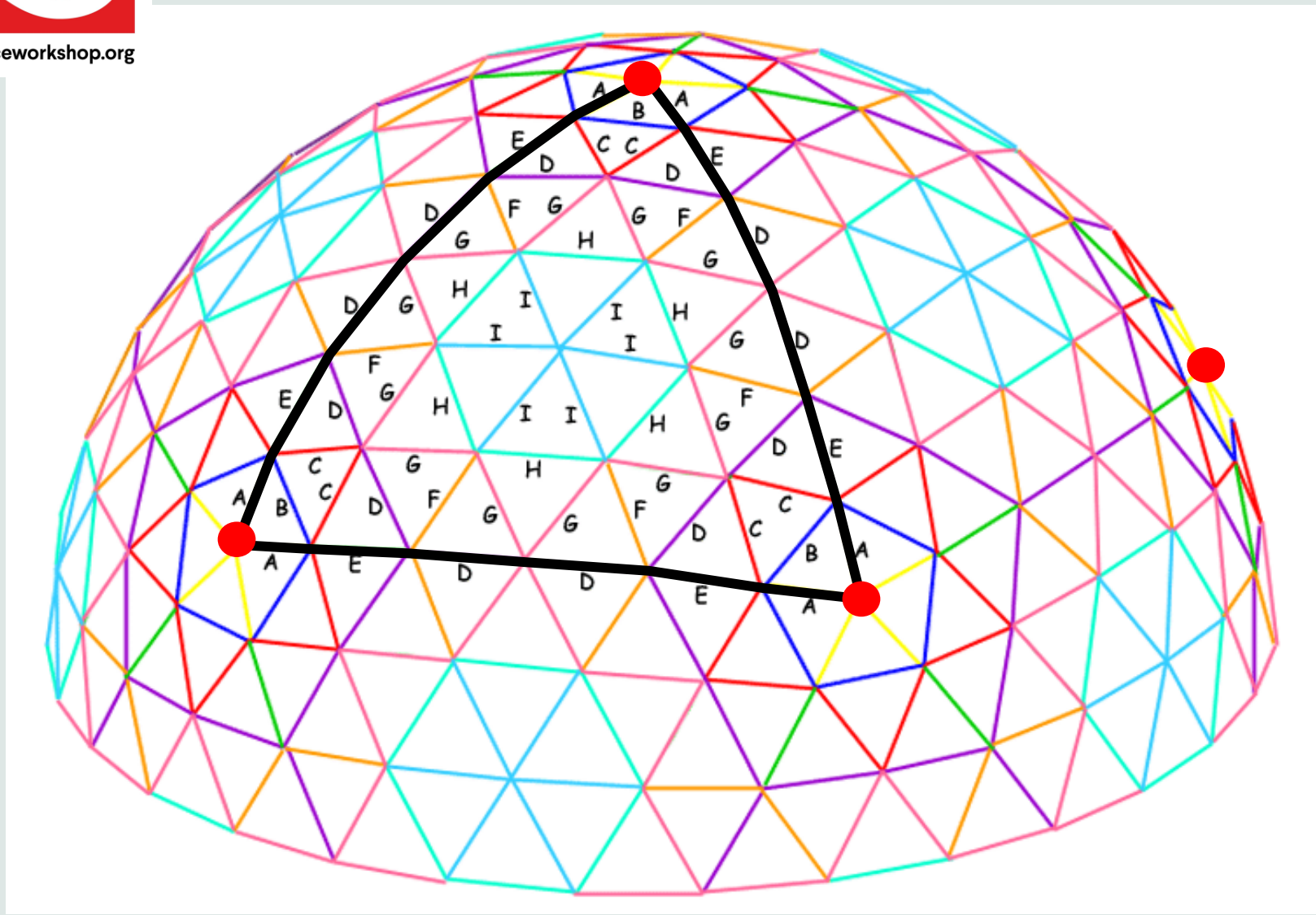
# Understanding the structure of the geodesic dome for connecting frames



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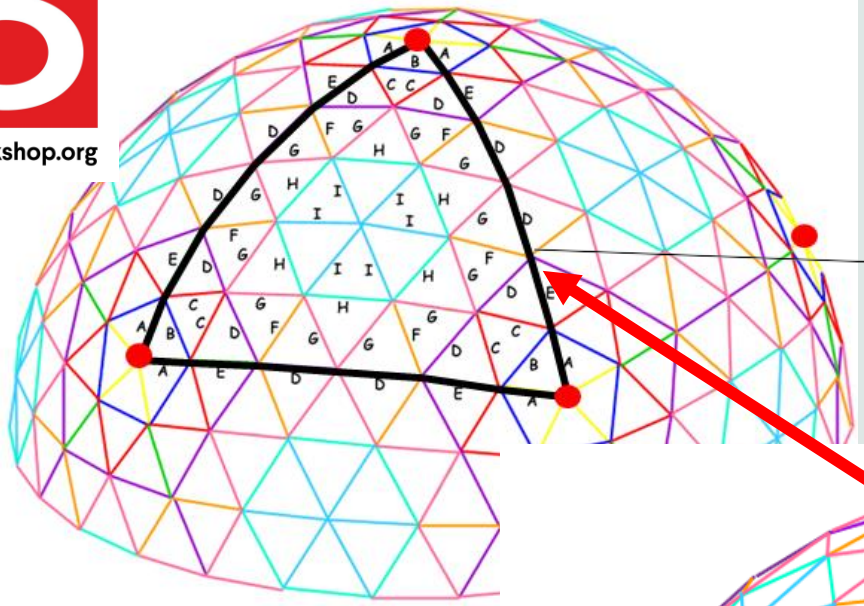
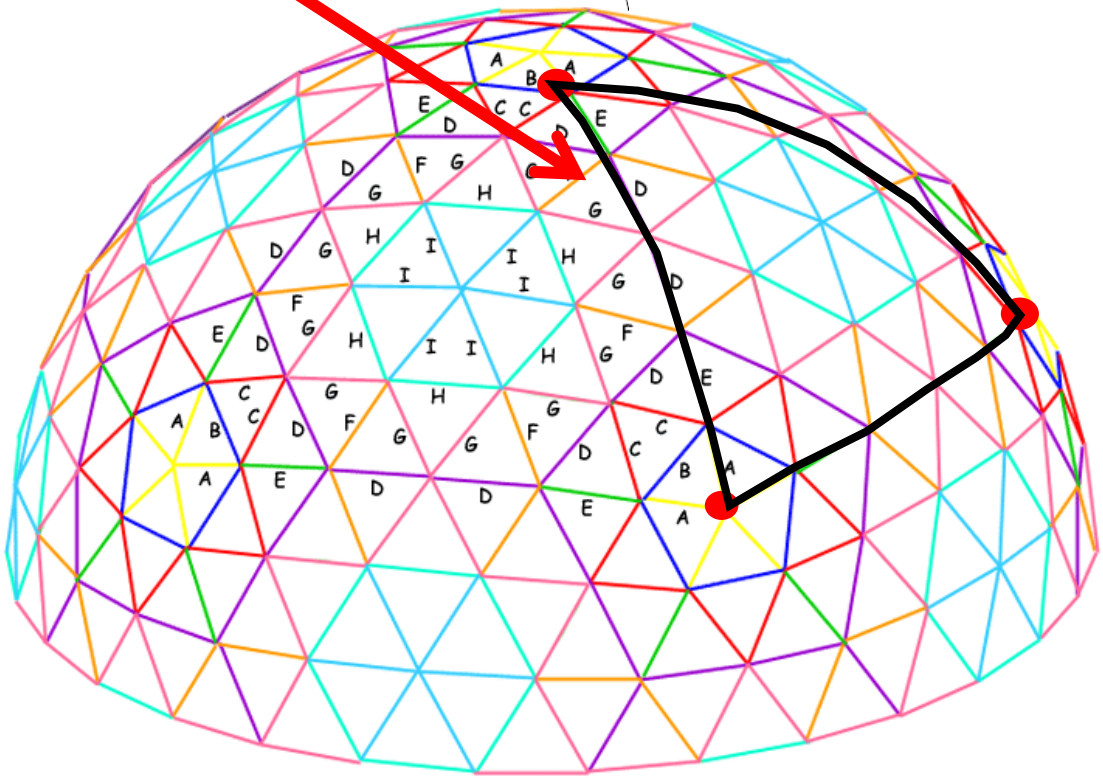
# Understanding the structure of the geodesic dome for connecting frames



A curved-line triangle



These two curved-line triangles are congruent to each other. Also the inner connecting structures are exactly the same. The central vertex (red point) of the top pentagon has 5 congruent curved-line triangles and can be covered by these 5 triangles exactly. It means that by the rotation of 72 degree, these curved-line triangles are the same in the Geodesic-dome. Similarly, other 3 curved-line triangles can be obtained by further rotational transformations.

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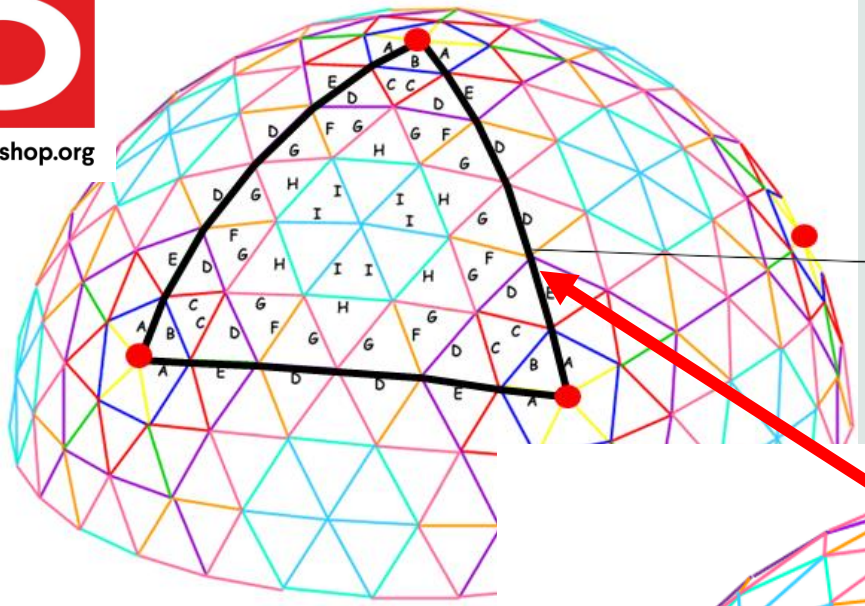
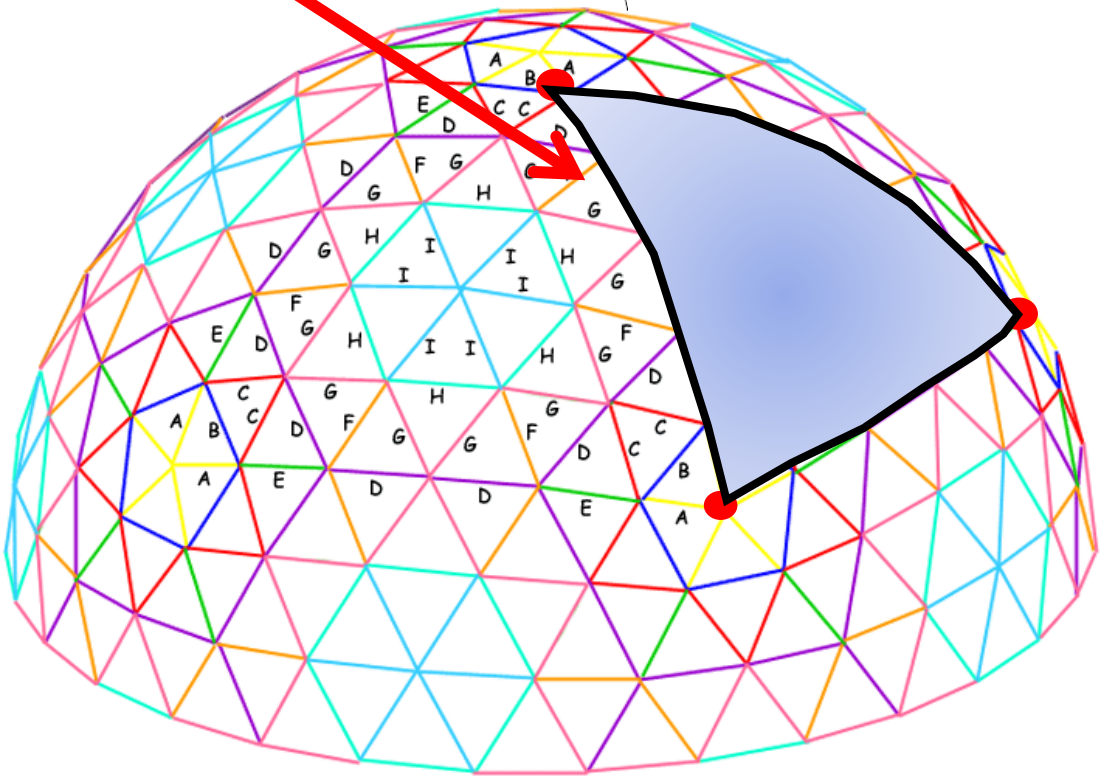
# Understanding the structure of the geodesic dome for connecting frames



A curved-line triangle



Inside part of the blue shaded region has the same connecting structure with that of the above curved-line triangle.

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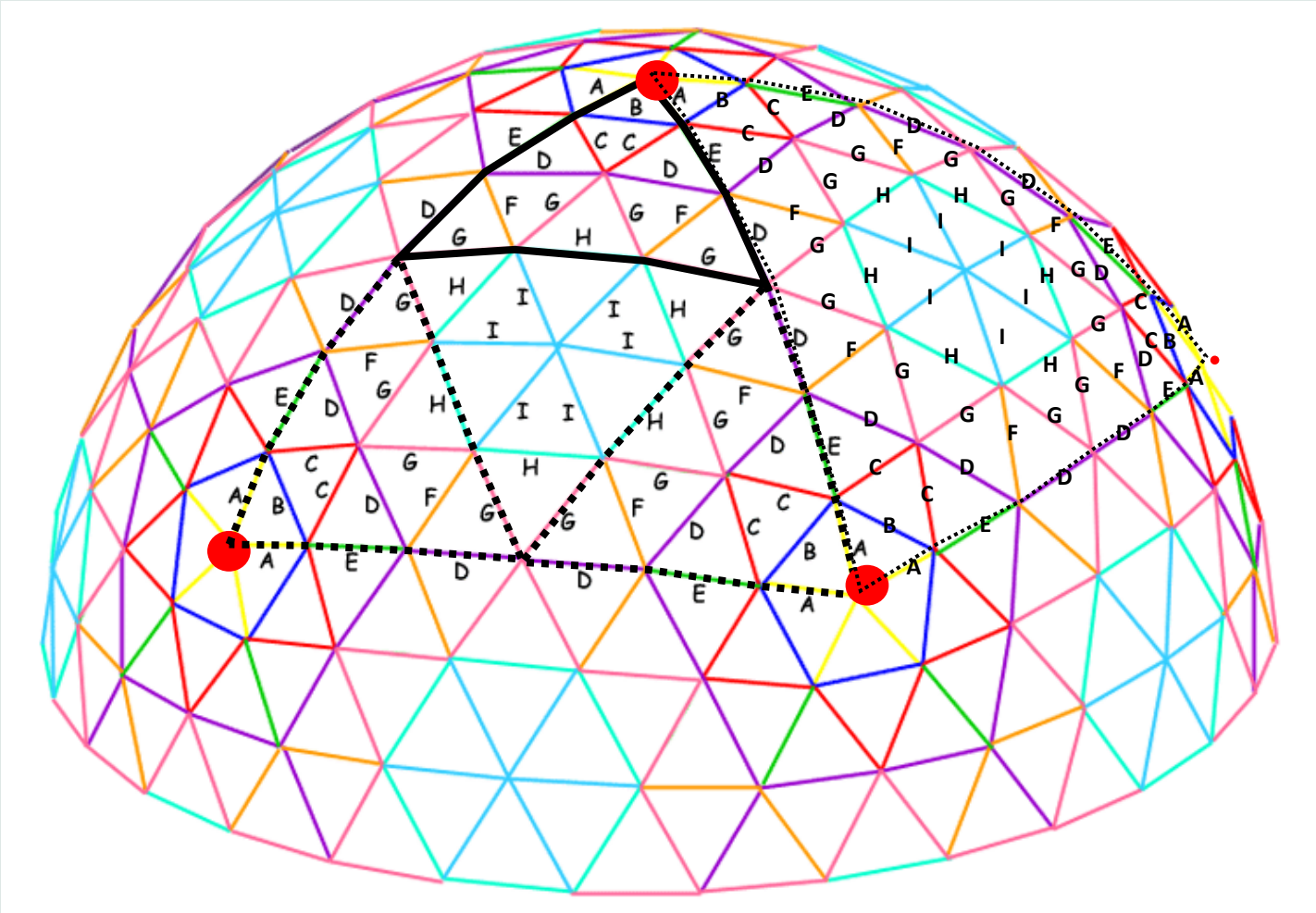
# Understanding the structure of the geodesic dome for connecting frames

Congruent triangular part of the curved-line triangle



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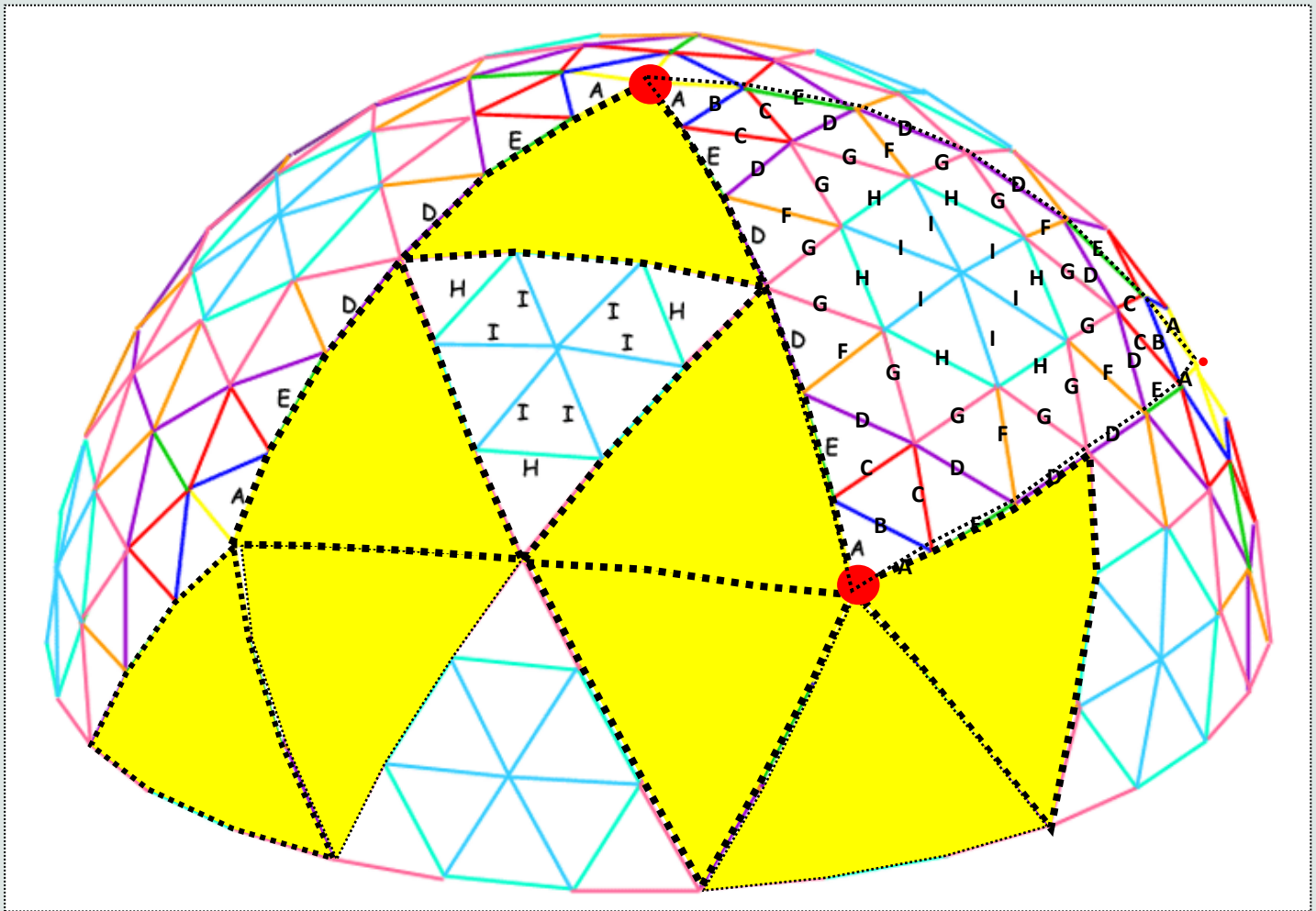
# Understanding the structure of the geodesic dome for connecting frames

These all yellow-shaded regions (curved-line triangles) are congruent to each other by adequate transformation (flip, or 72 degree rotation).



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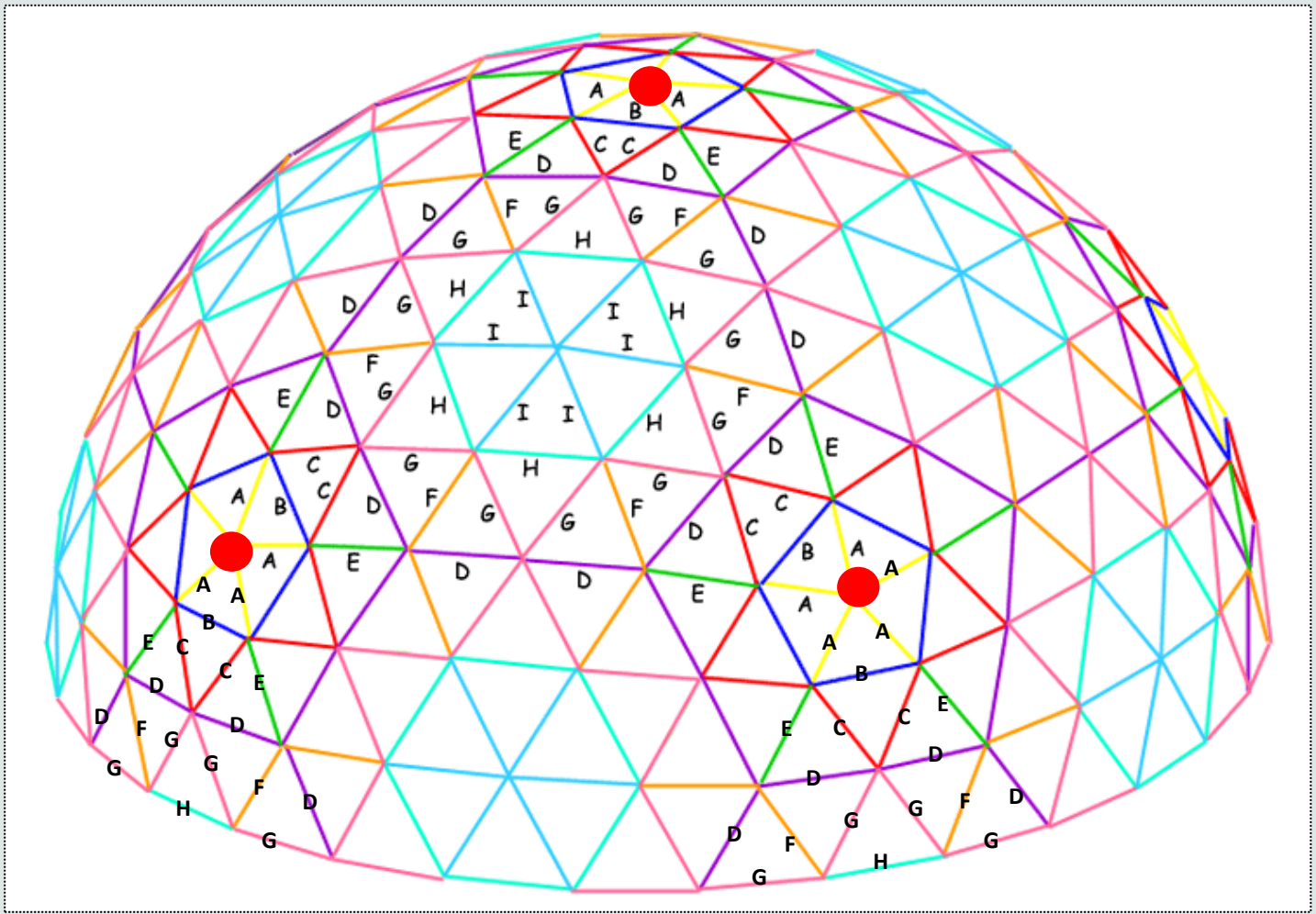
# Understanding the structure of the geodesic dome for connecting frames



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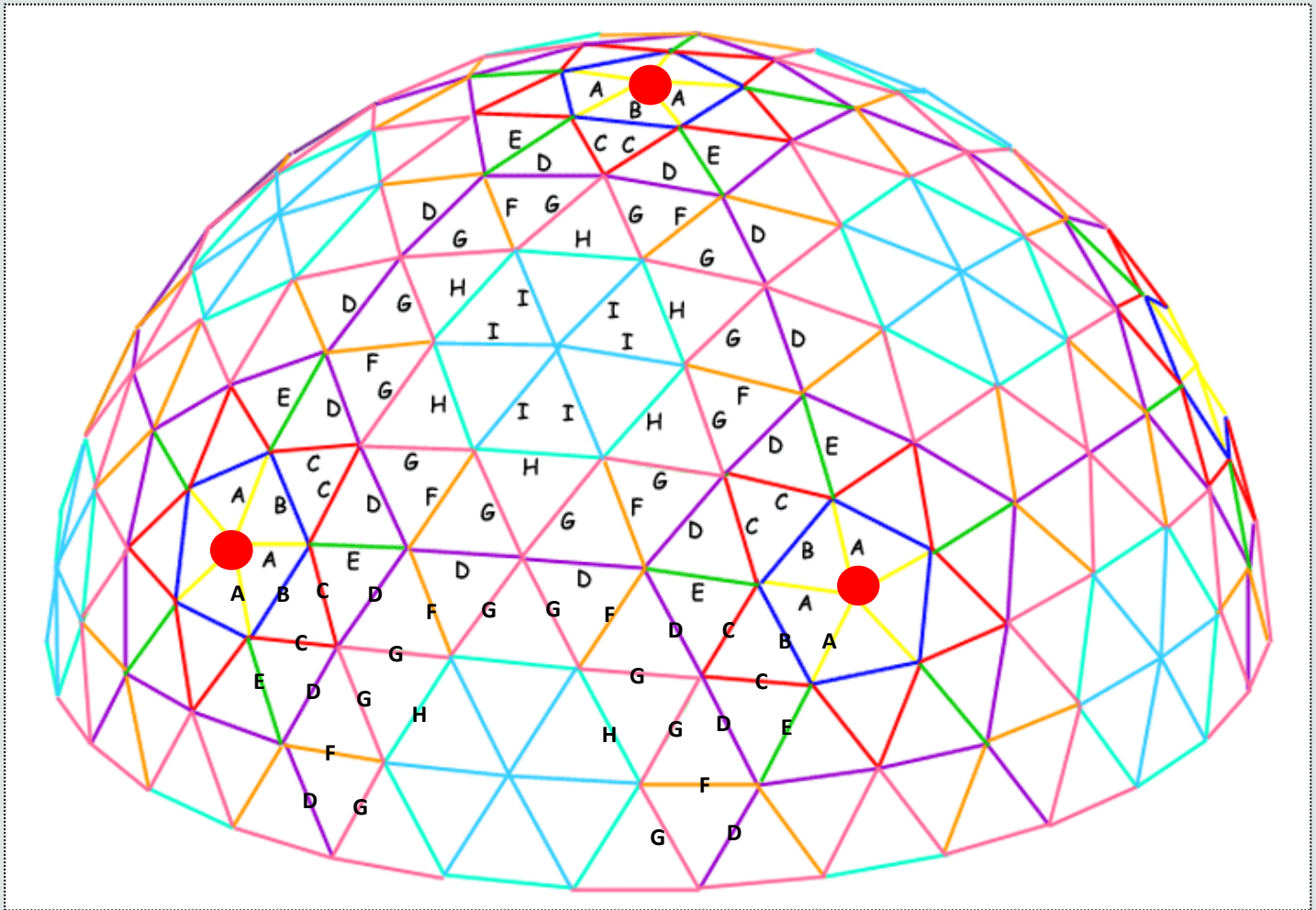
# Understanding the structure of the geodesic dome for connecting frames



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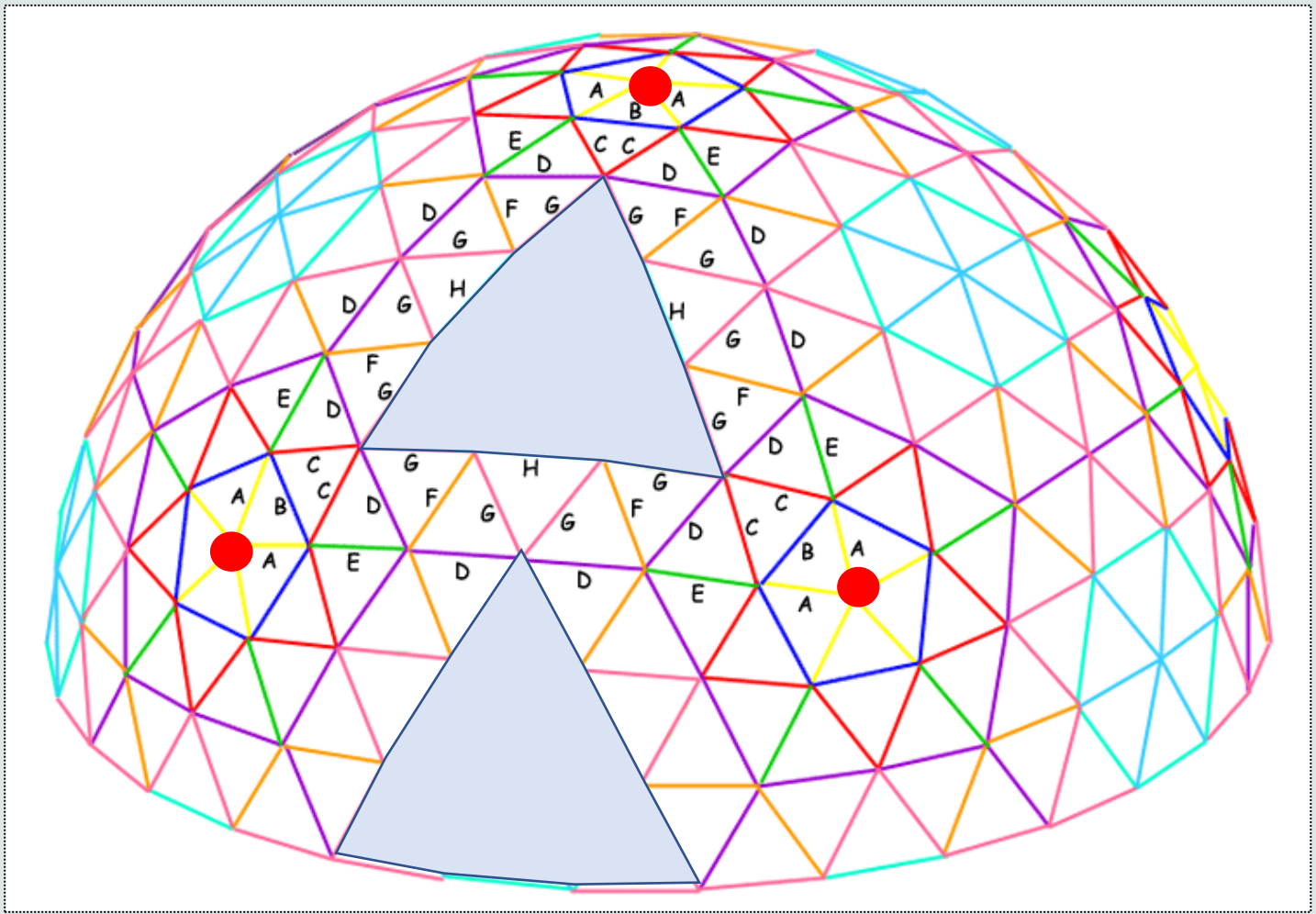
# Understanding the structure of the geodesic dome for connecting frames

These two blue-shaded regions (curved-line triangles) are congruent to each other by adequate transformation



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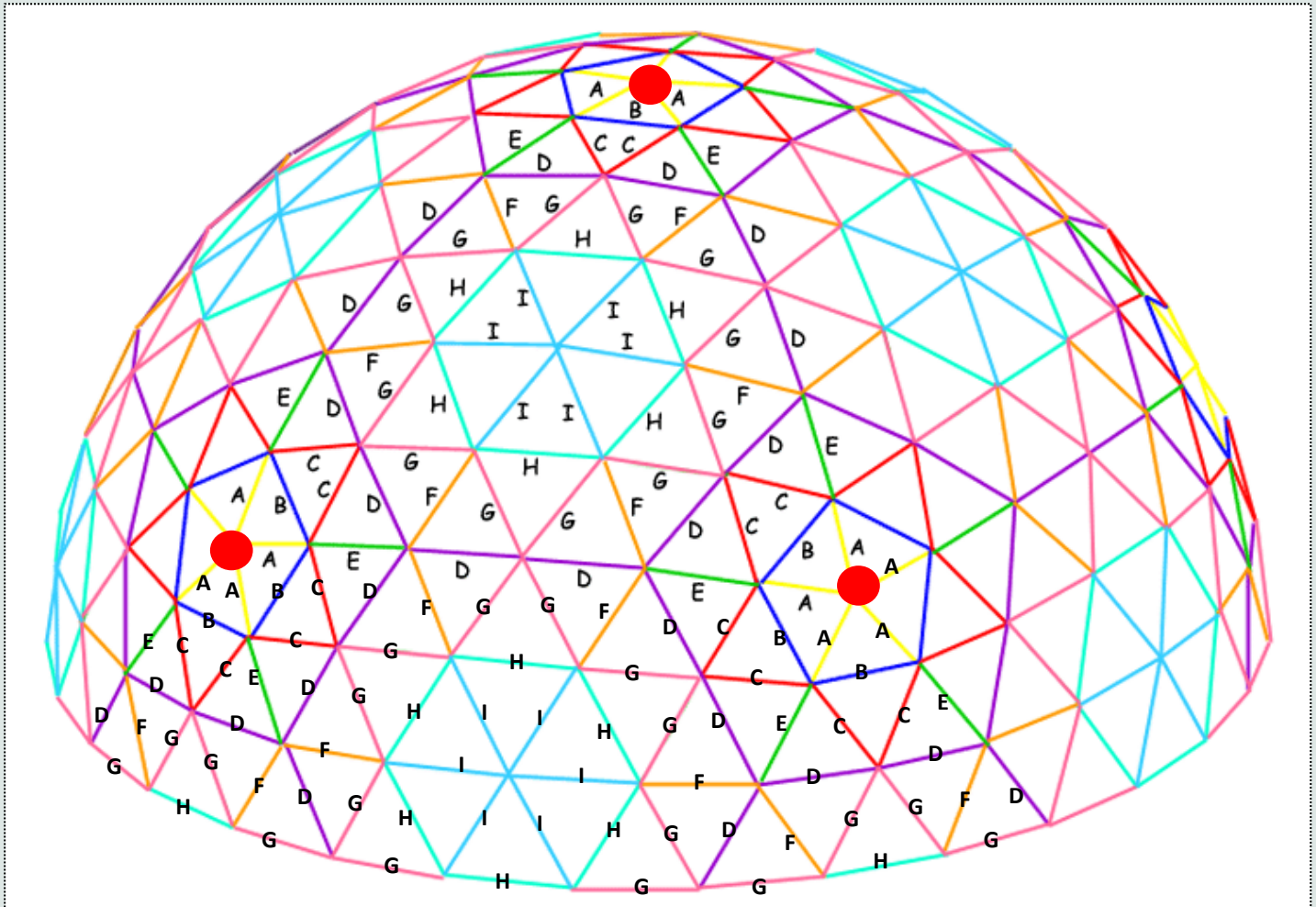
# Understanding the structure of the geodesic dome for connecting frames

One of the 5 congruent parts of the Geodesic Dome



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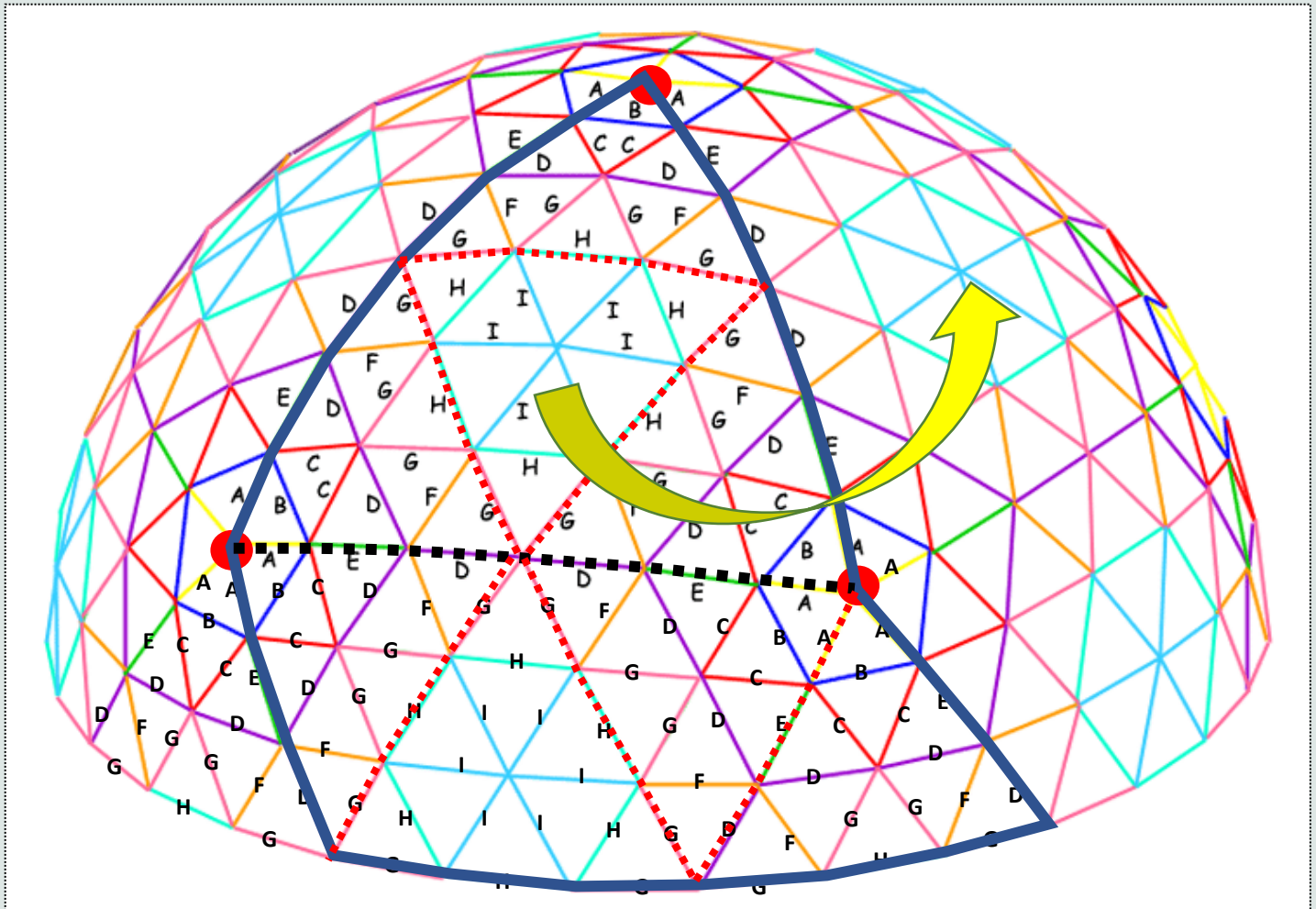
# CONCLUSION

72-degree rotation by the AXIS of the geodesic dome at the center of the top pentagon



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# Constructing the Geodesic Dome

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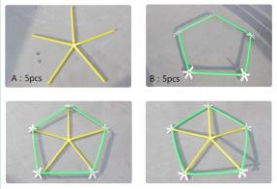
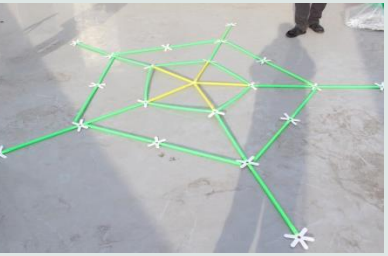
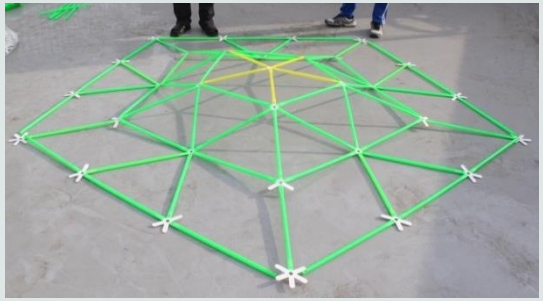
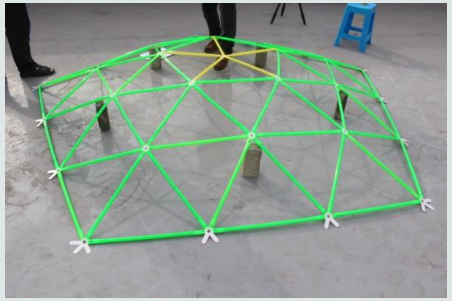
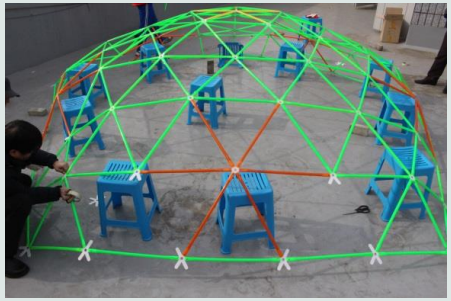
# The Construction Process of the Geodesic Dome

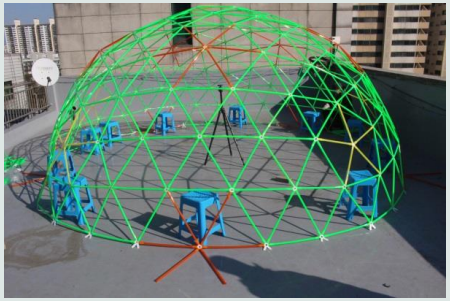


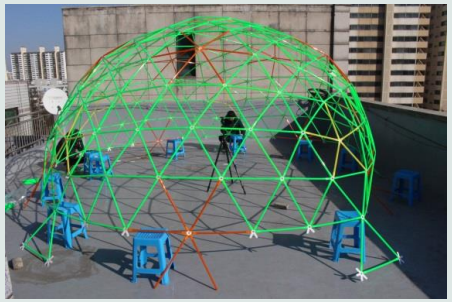



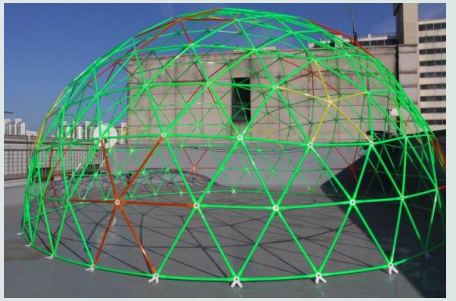












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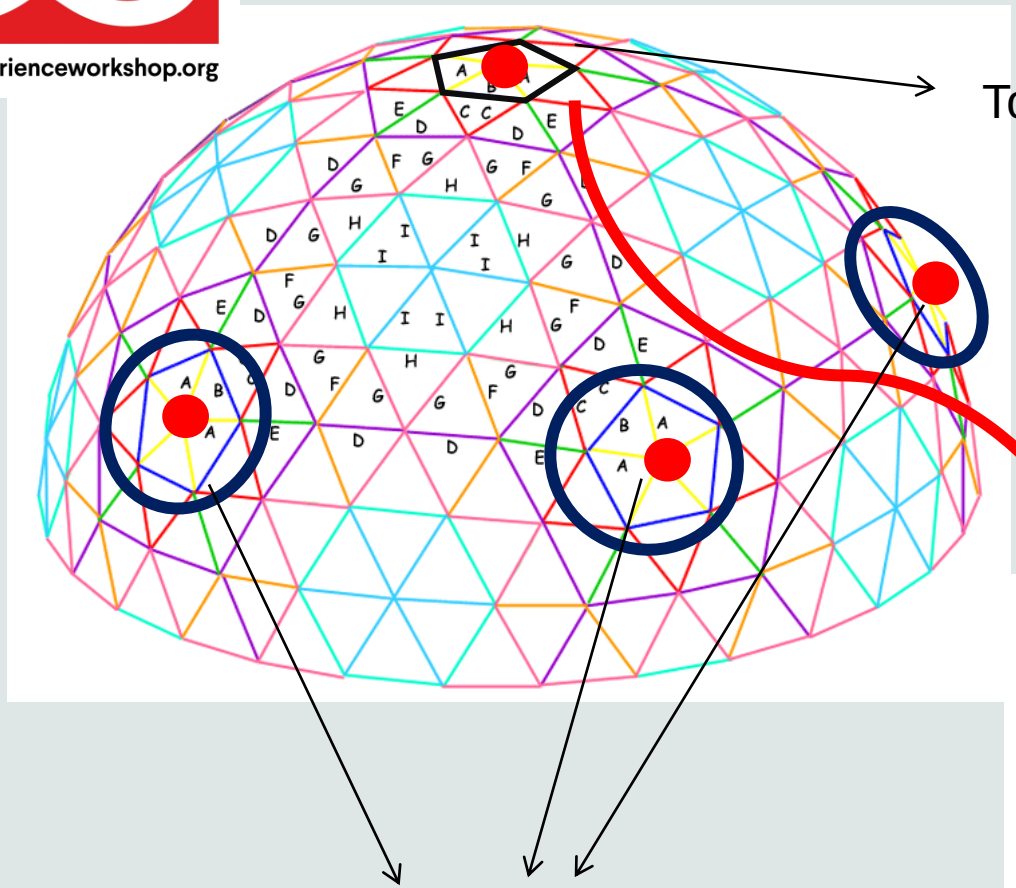
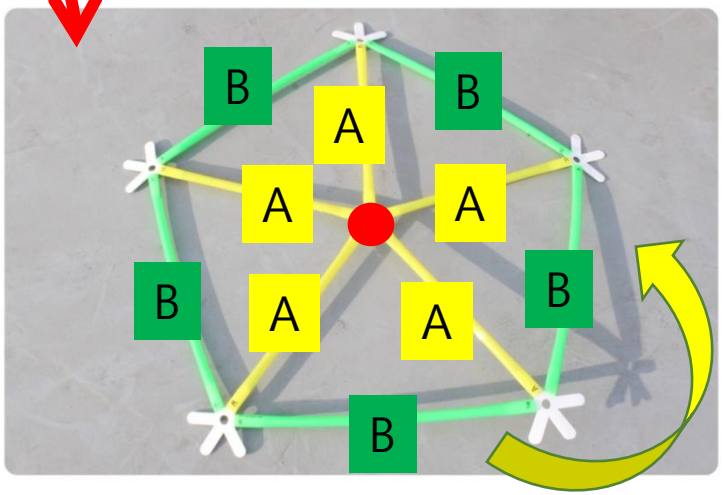
# Top part Pentagon



Top part pentagon

Side part 5 pentagons




Top part pentagon

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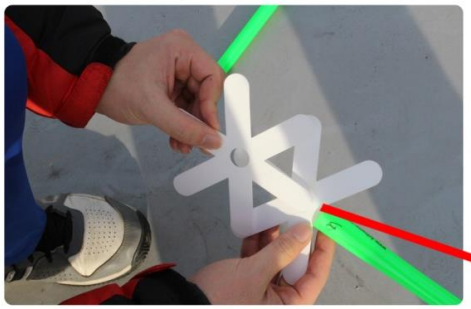
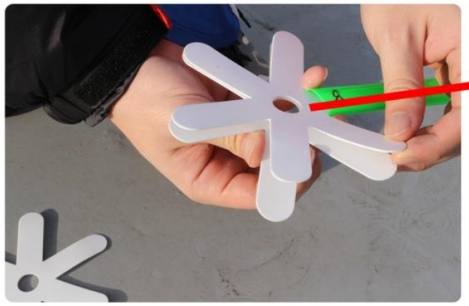
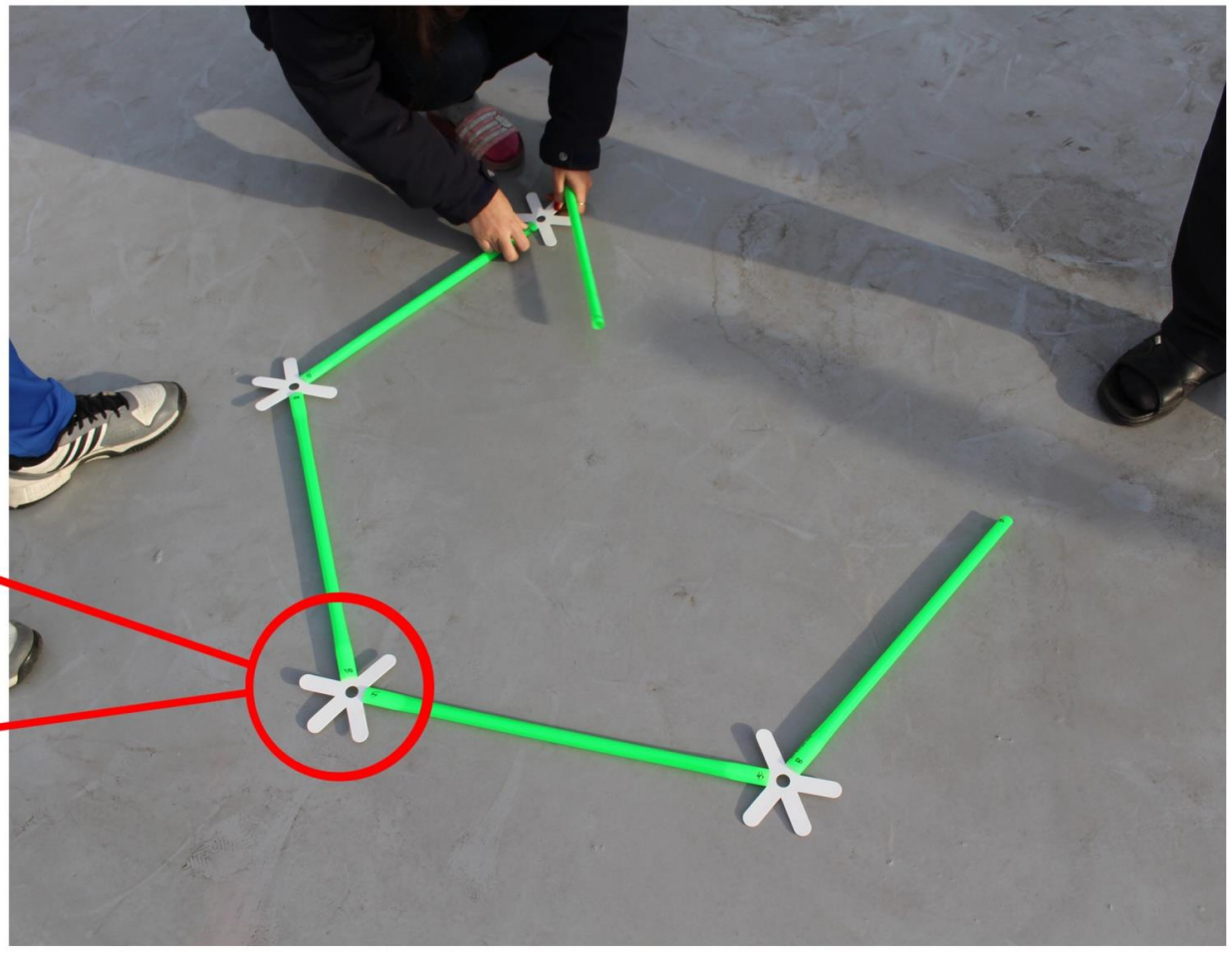
# Top part Pentagon





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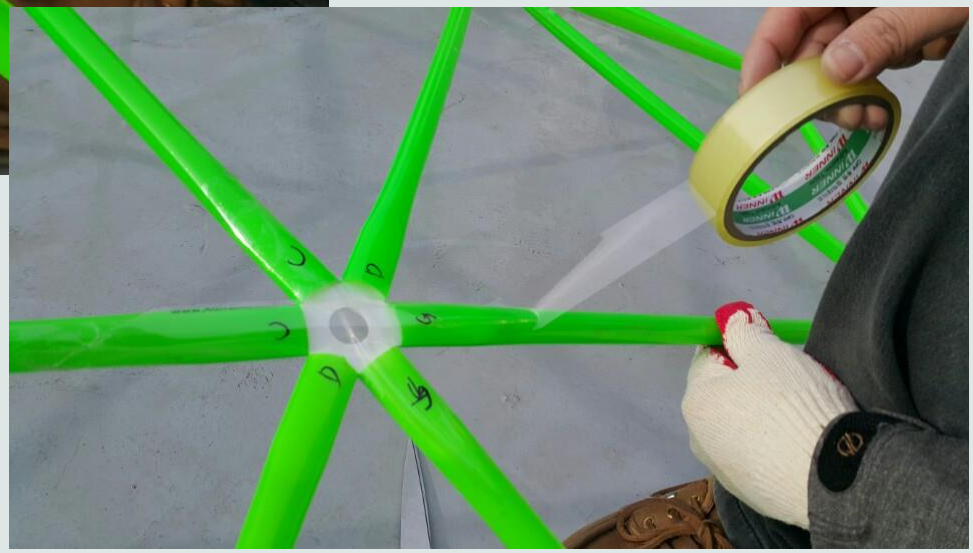
# Taping method at each vertex



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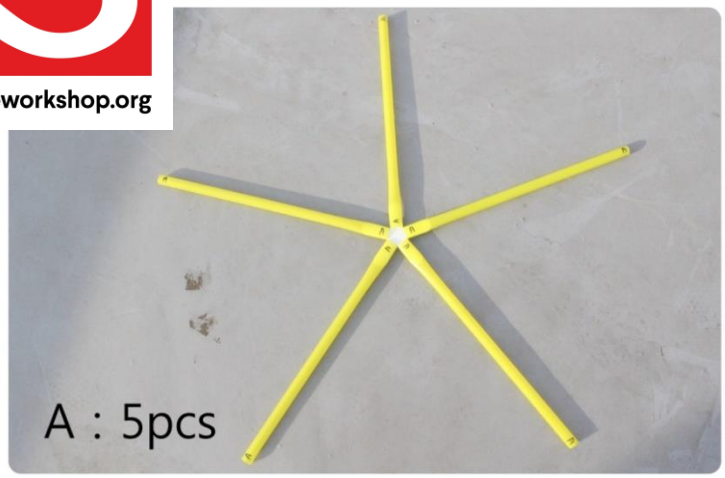
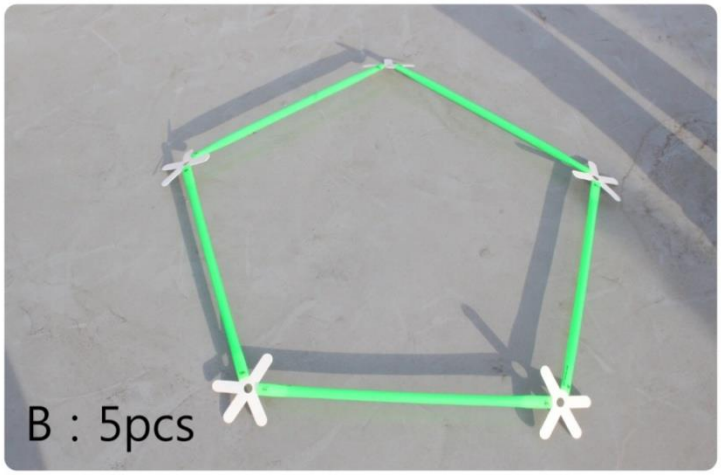
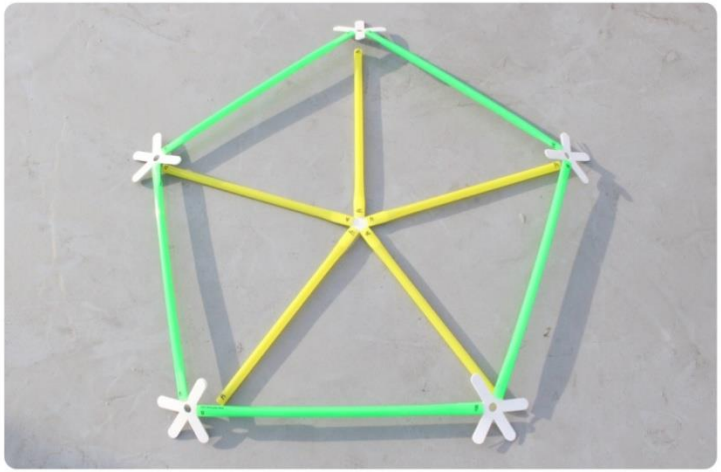
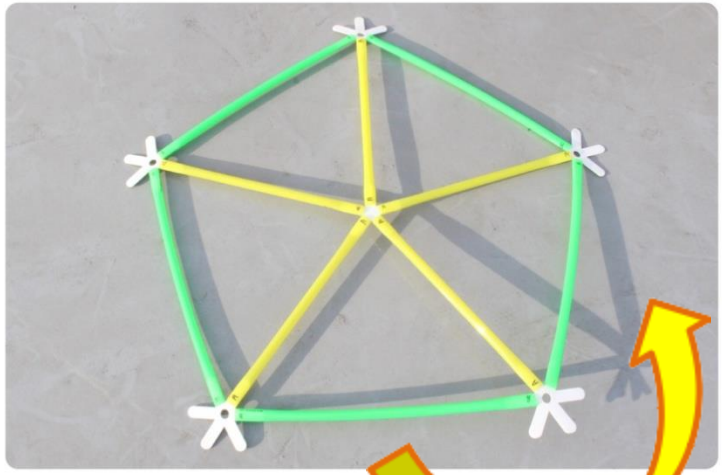
# The Process of Connecting





Please use double tapes in the center of the pentagon.

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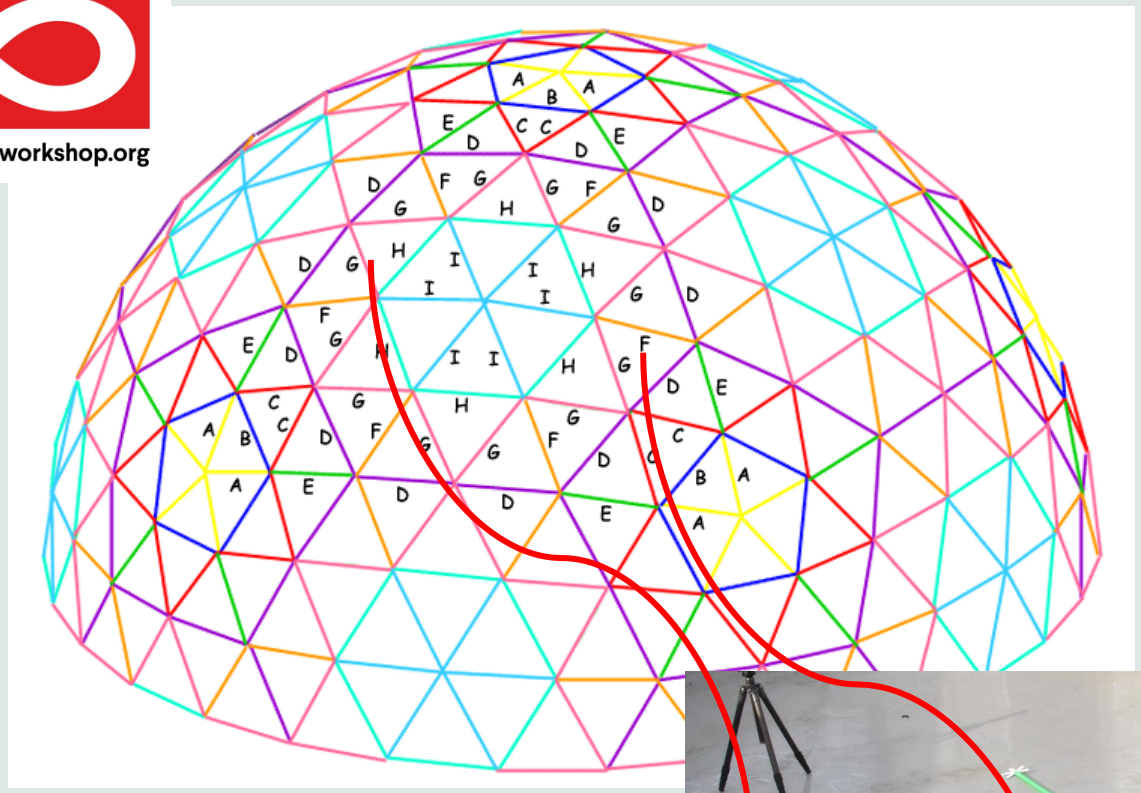

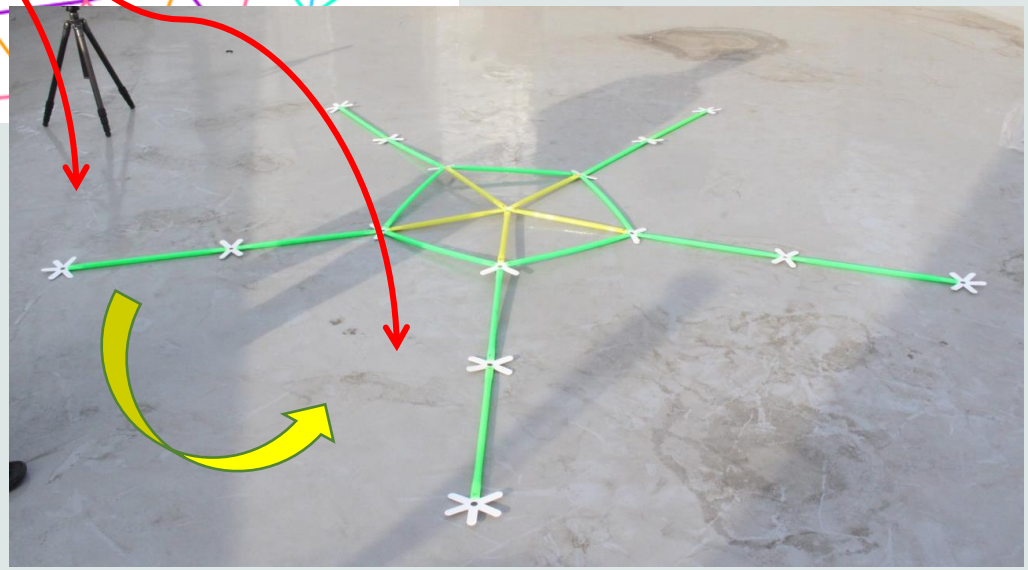

Build the 5 congruent triangles

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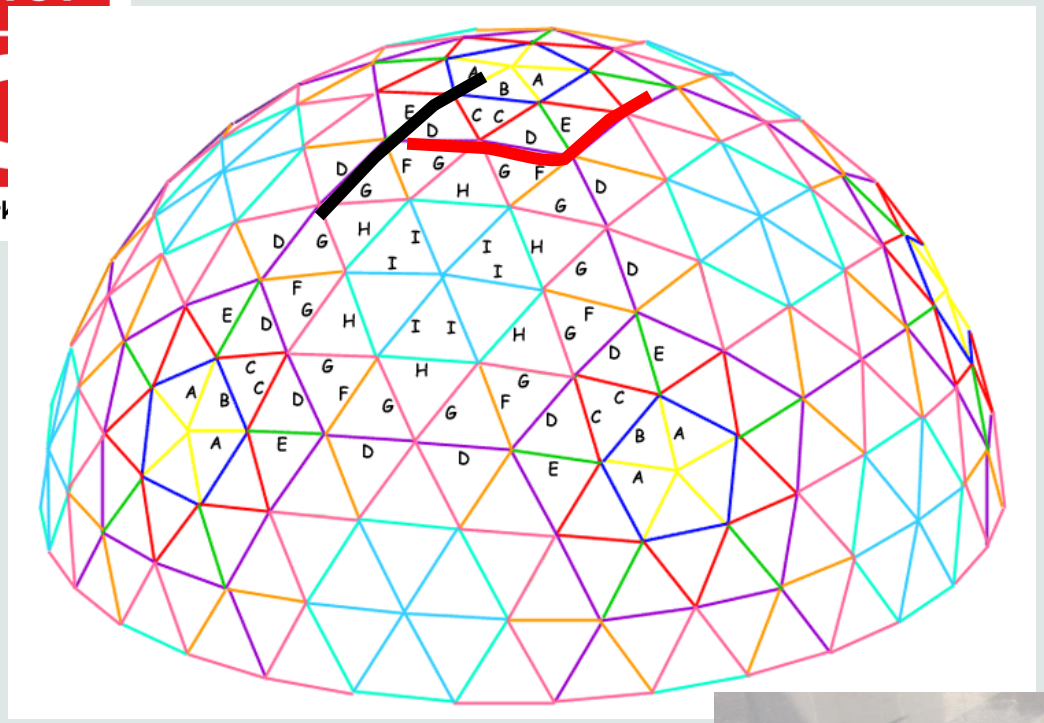

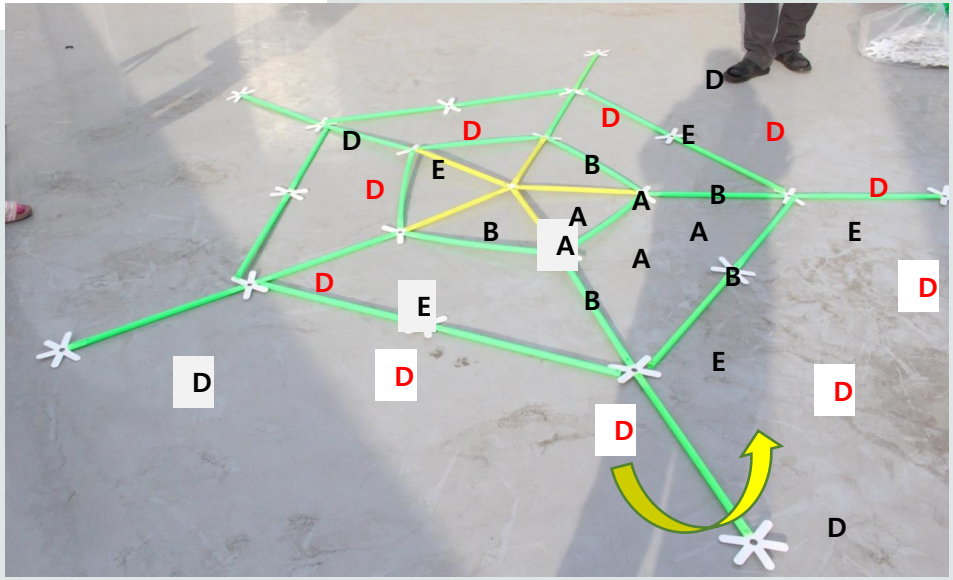

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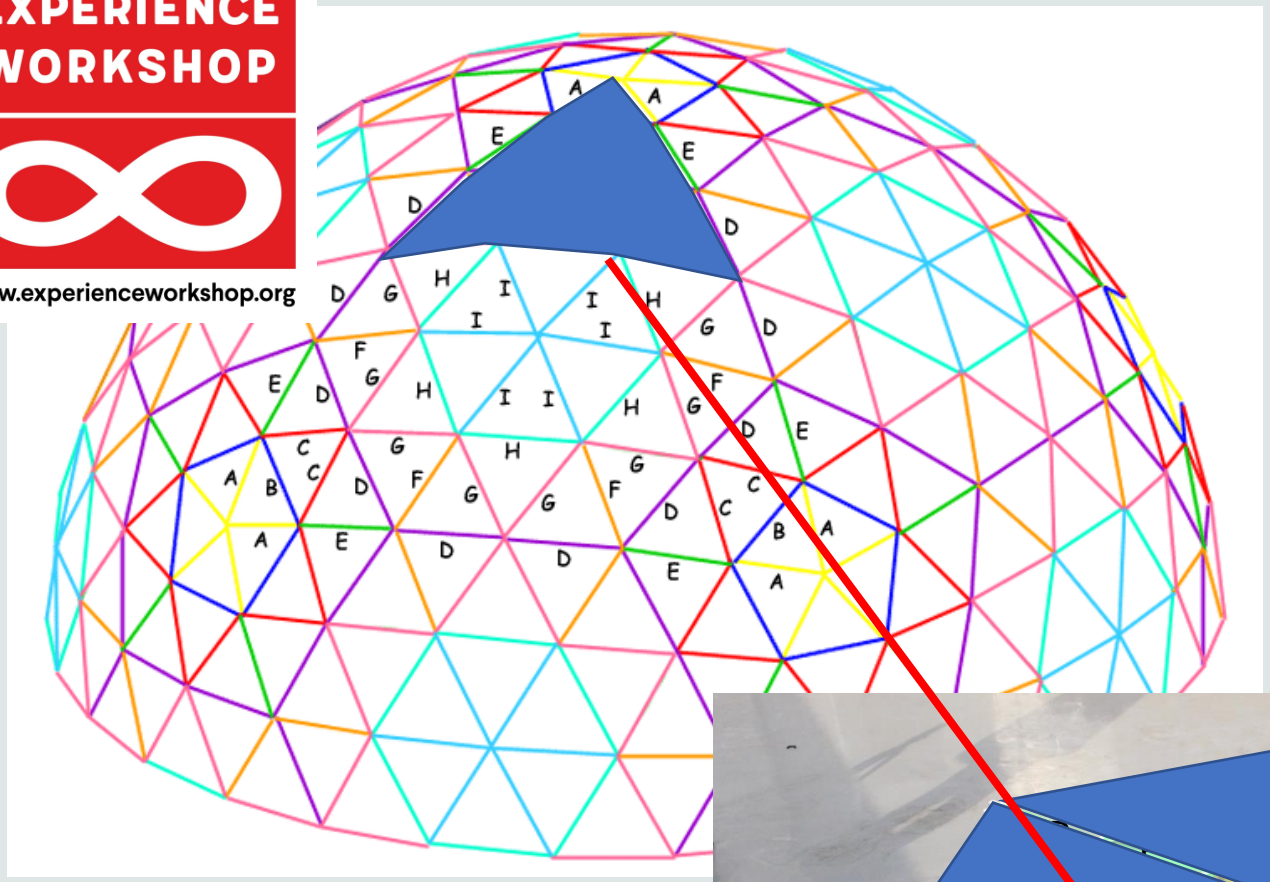

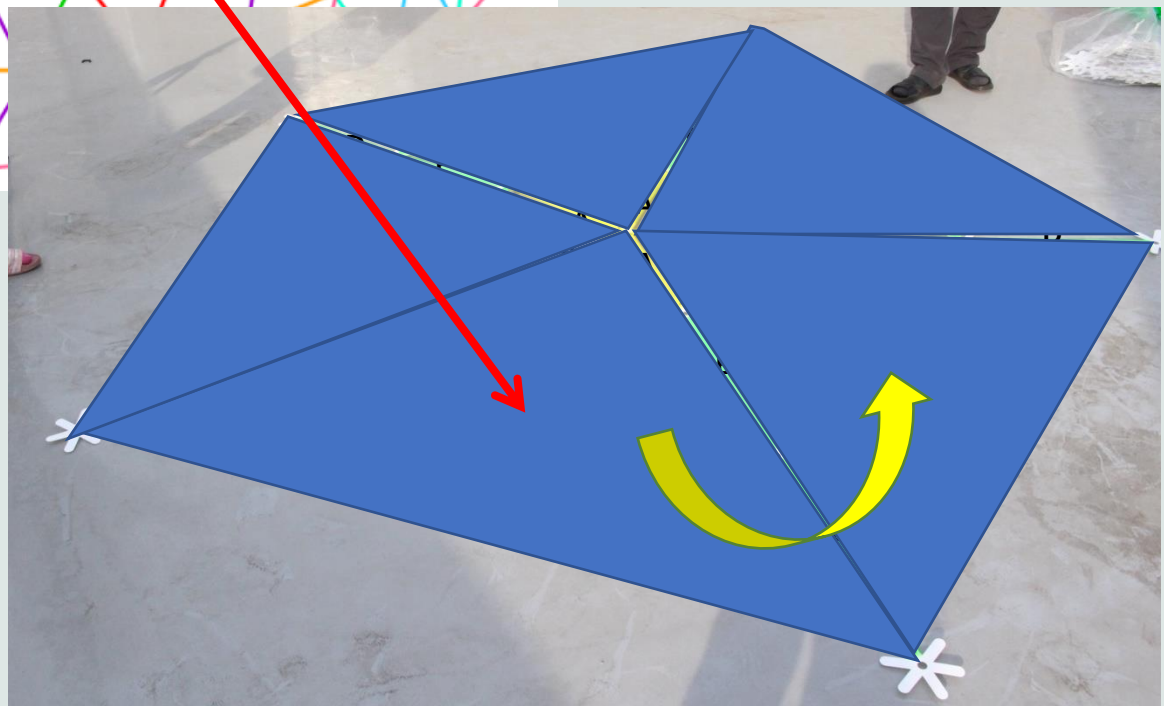

72 degree rotation by the axis of the geodesic dome at the center of the top pentagon

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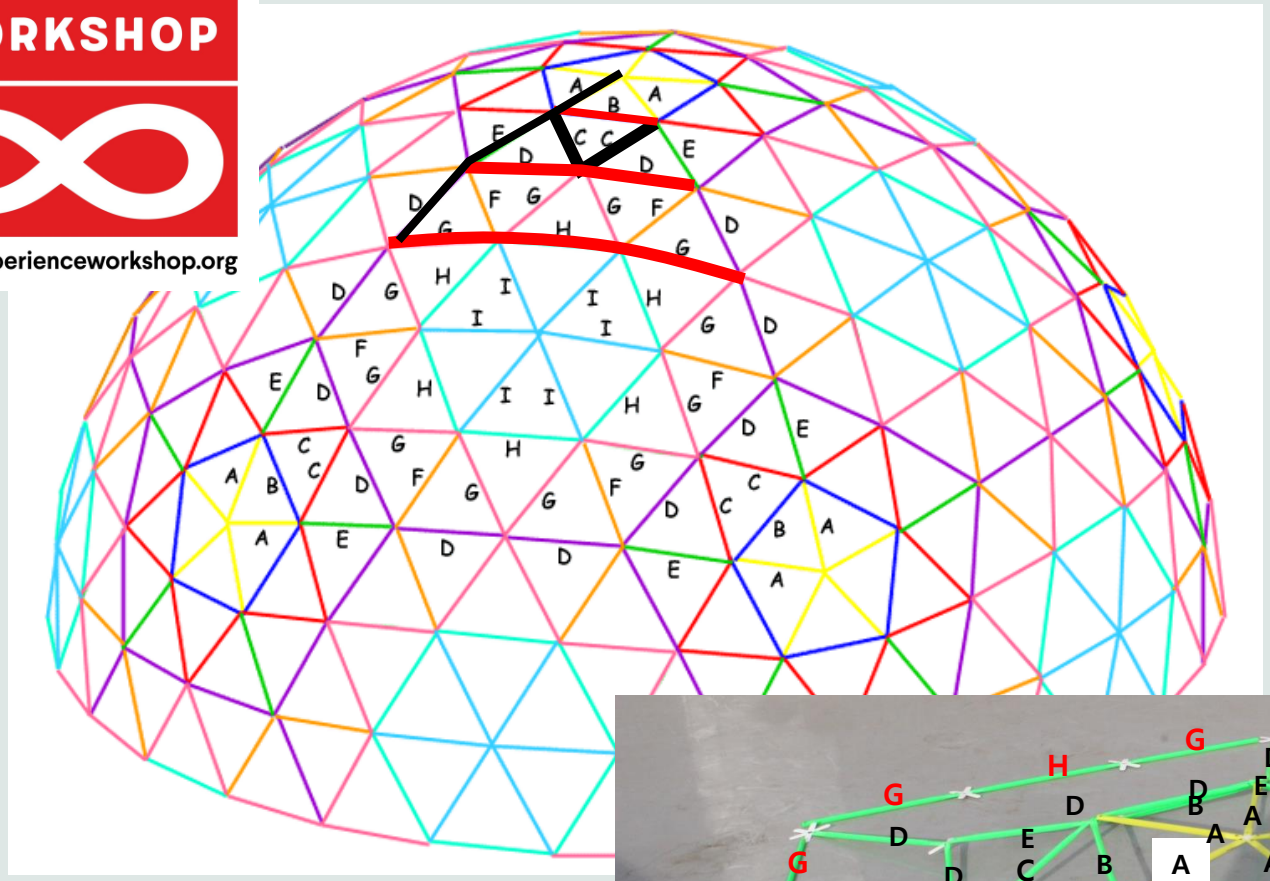

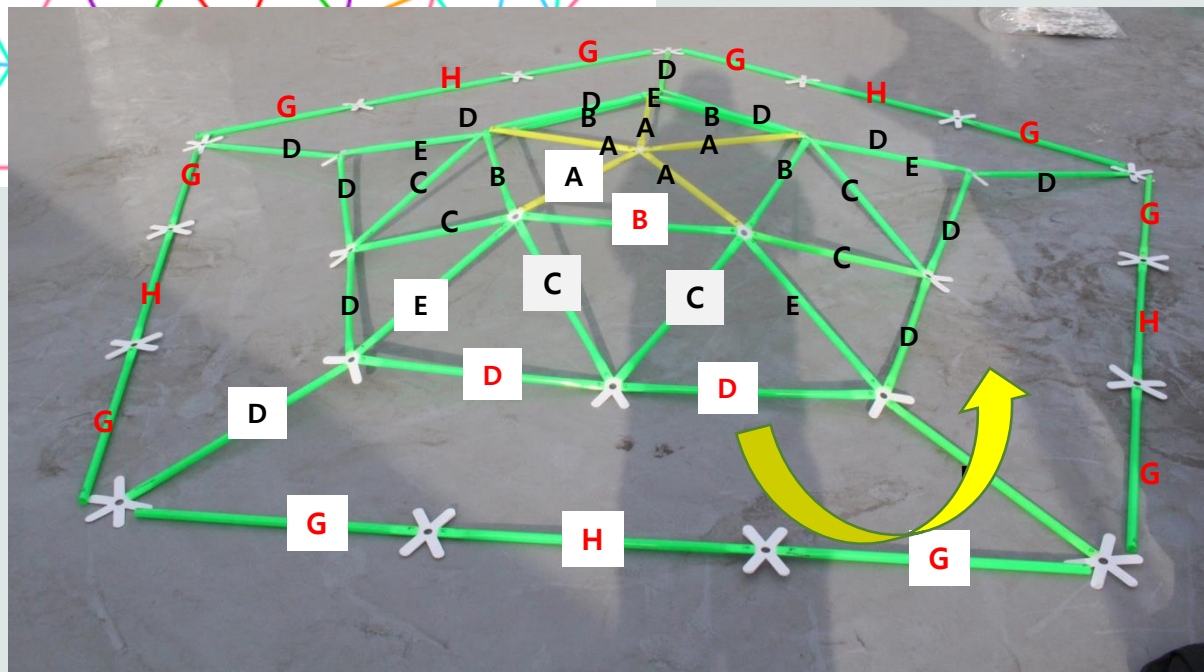

Proceed to connect by this method

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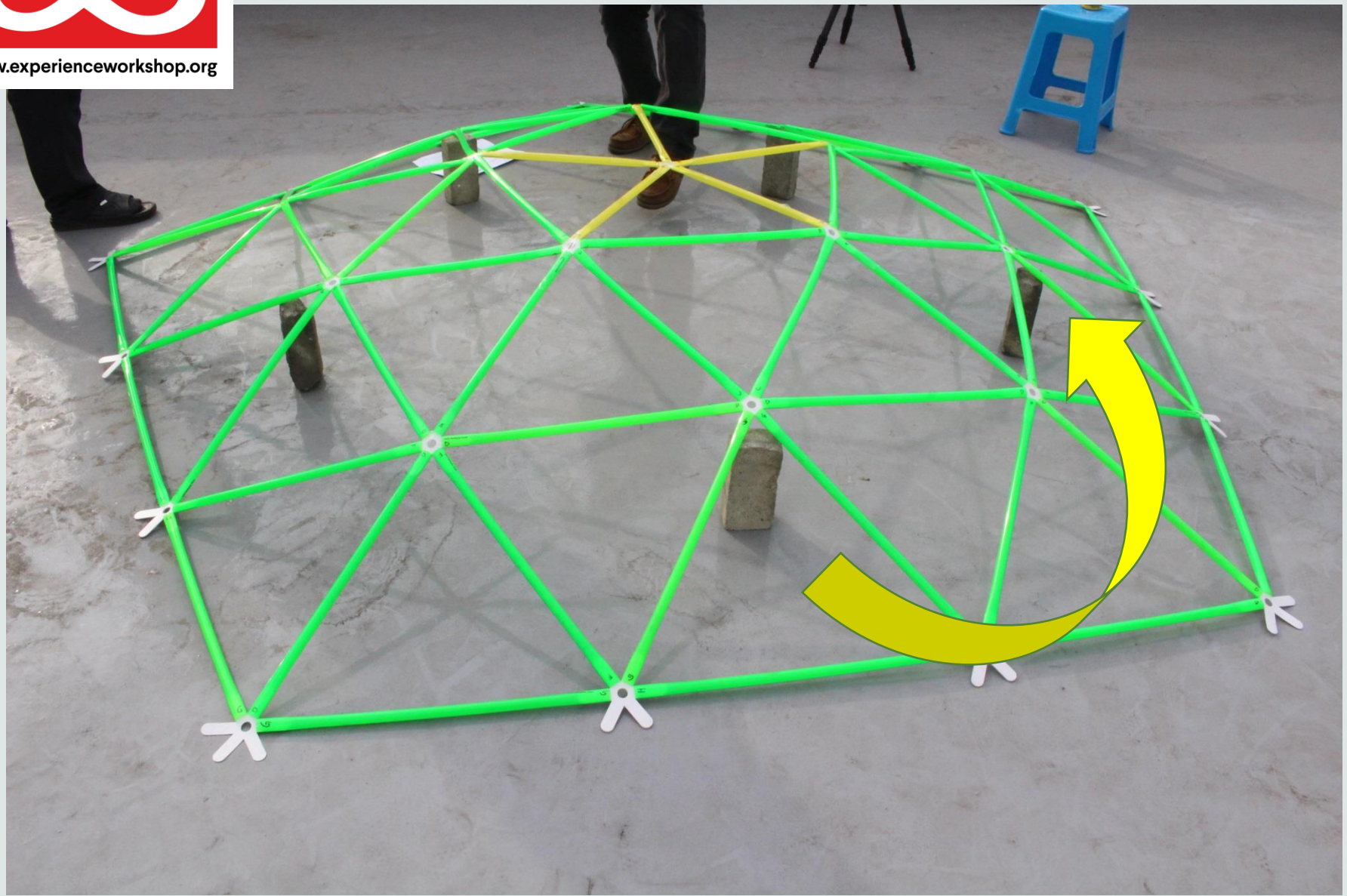

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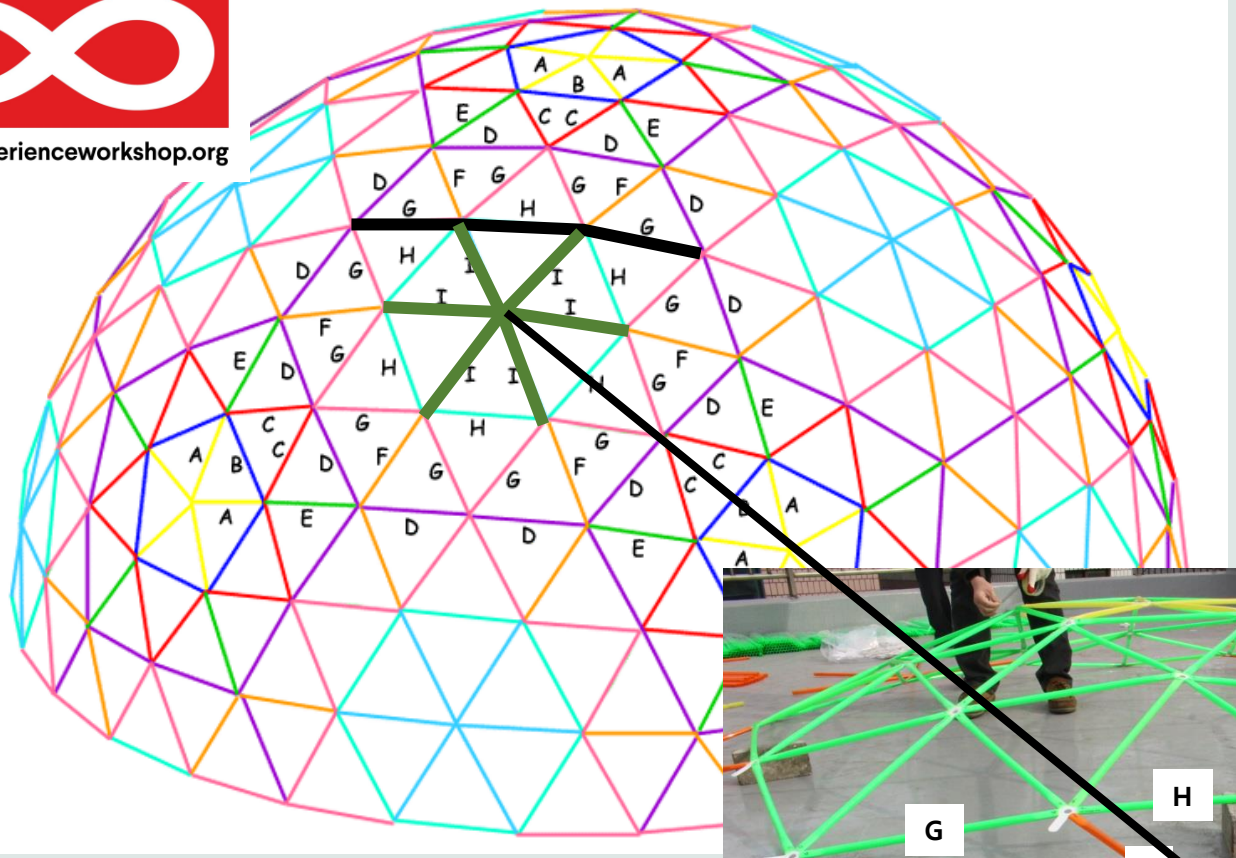


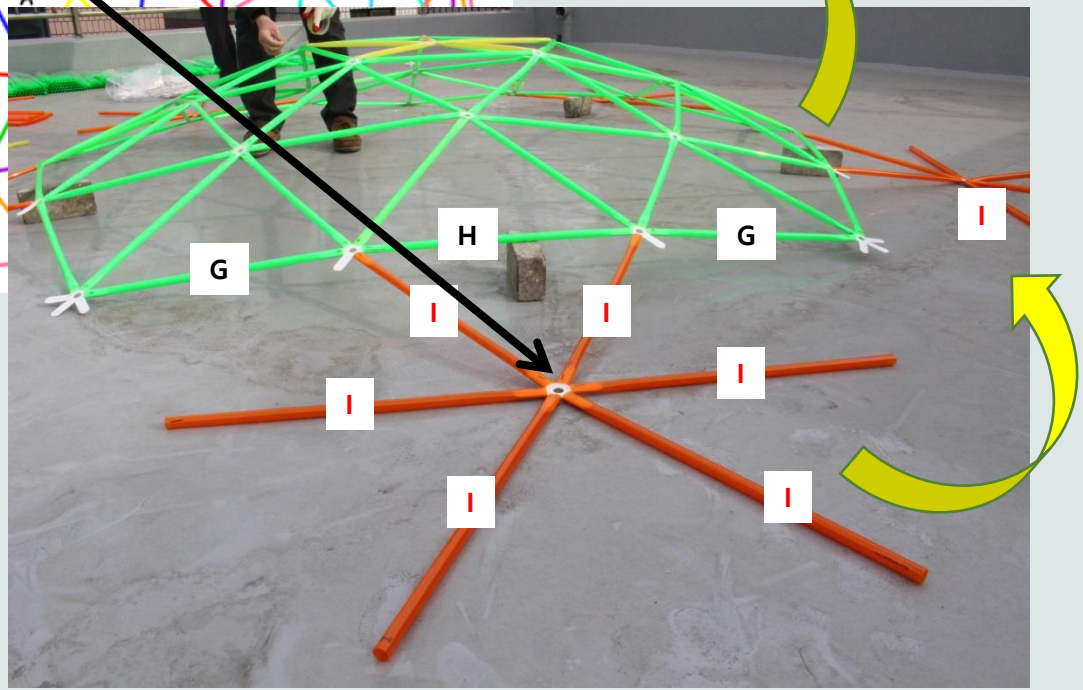

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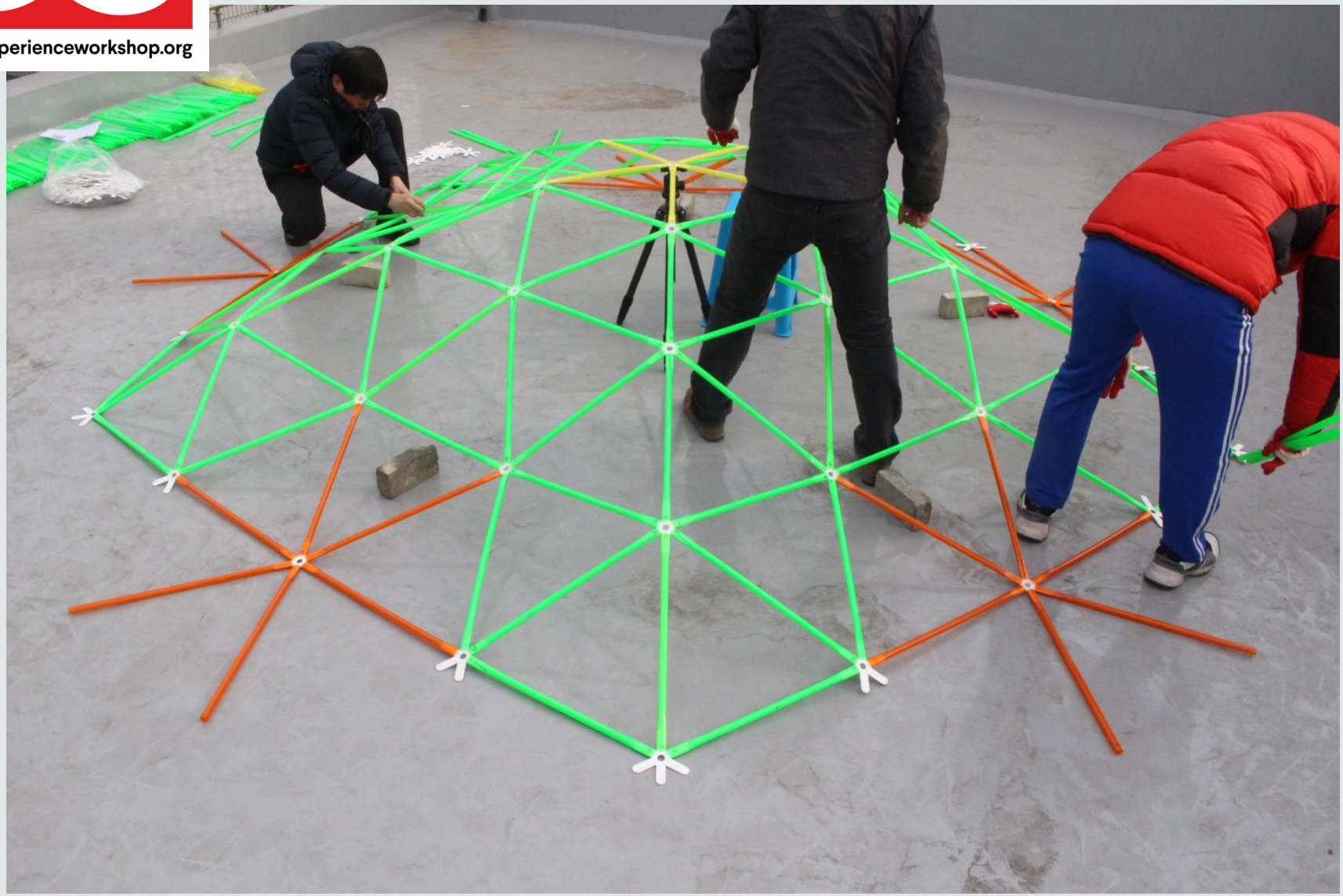

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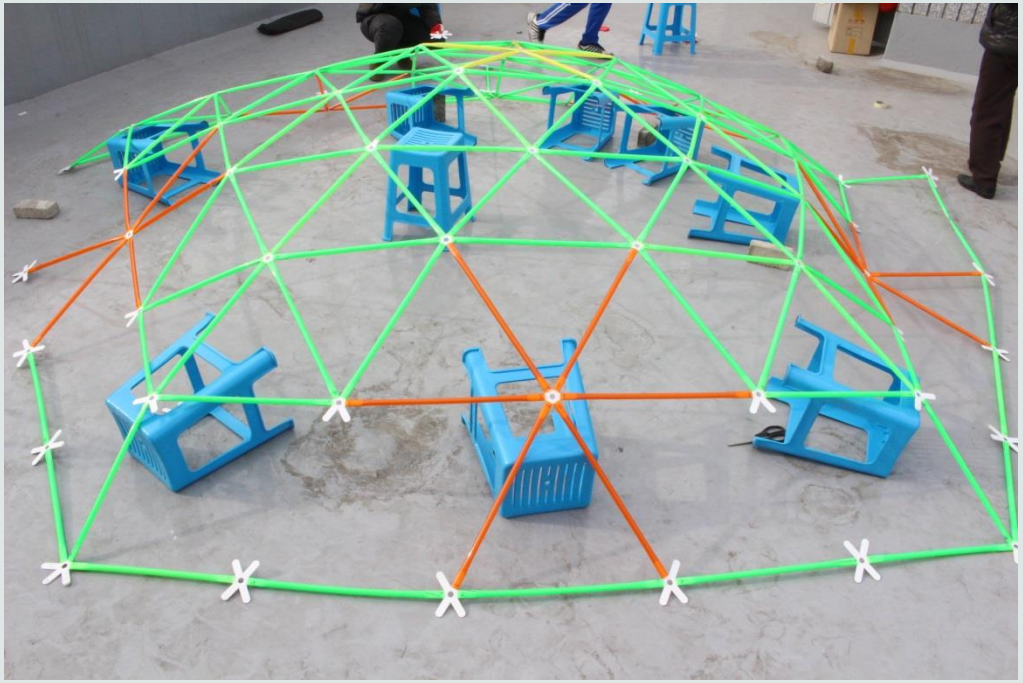

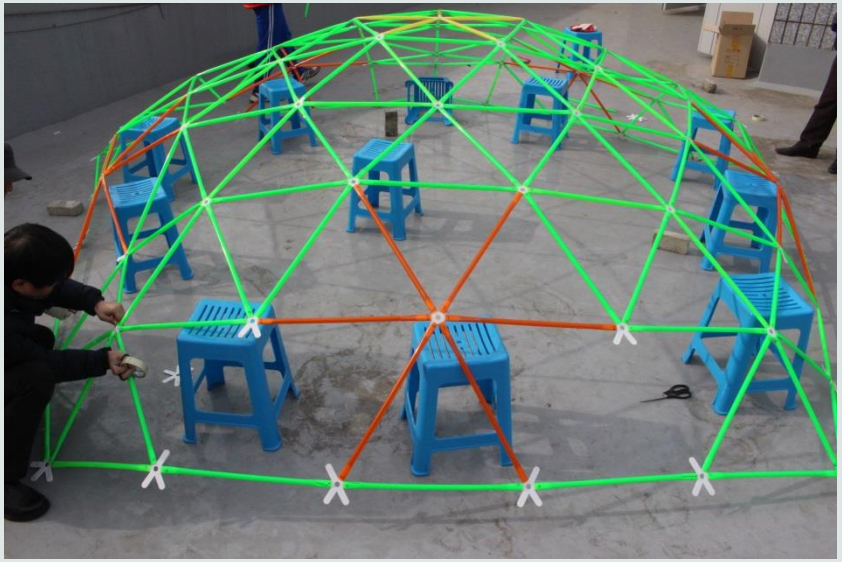

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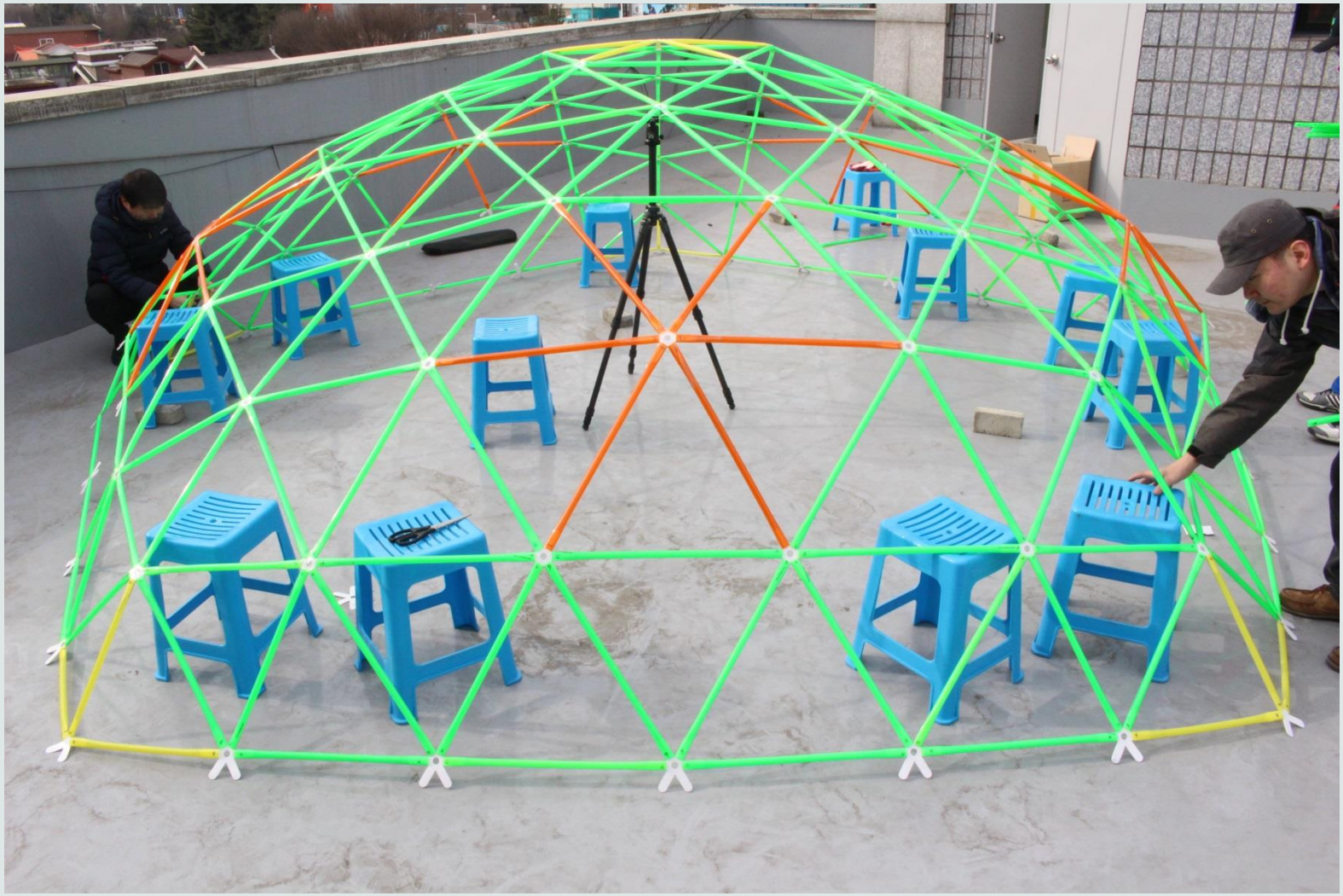

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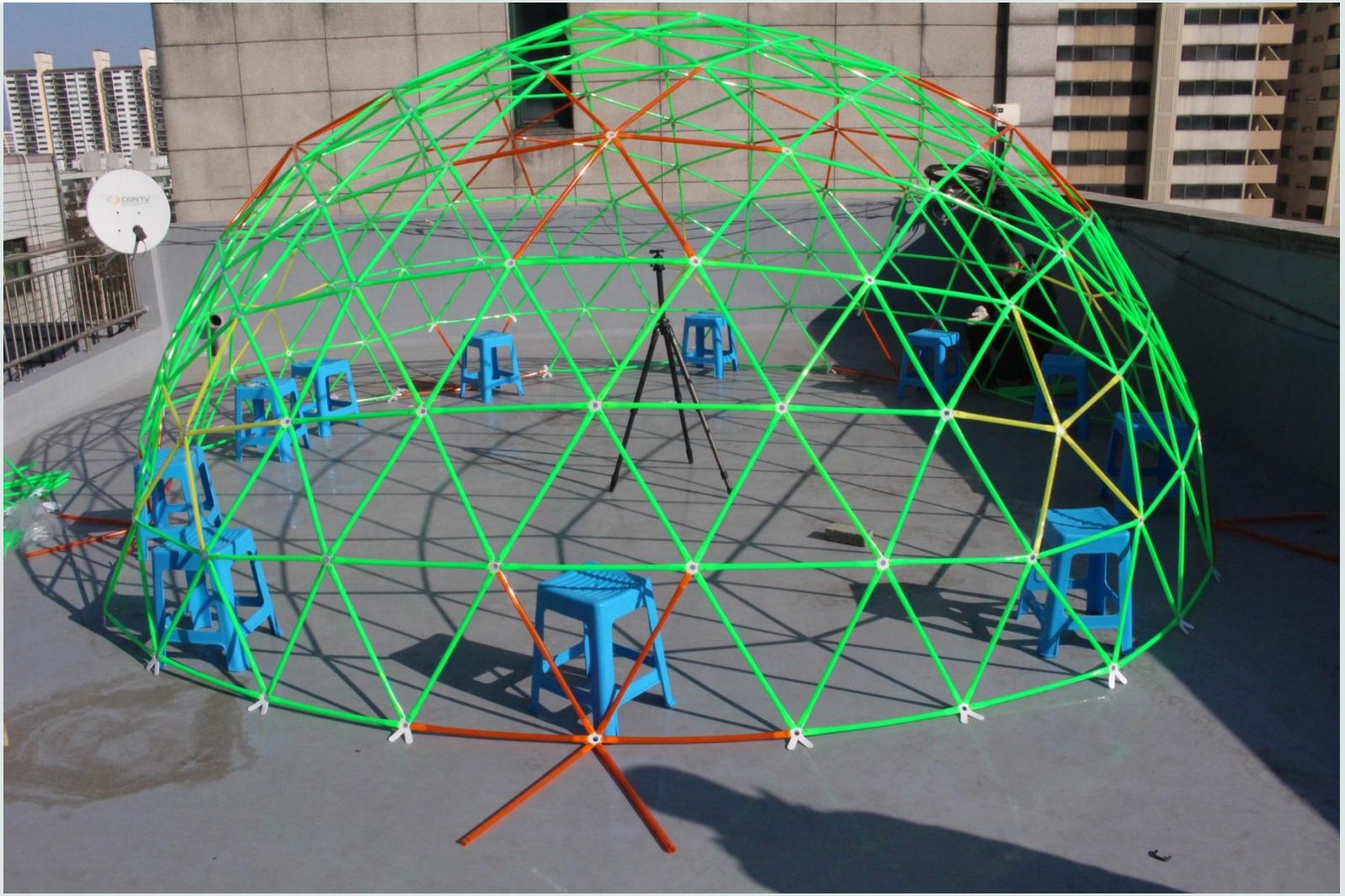

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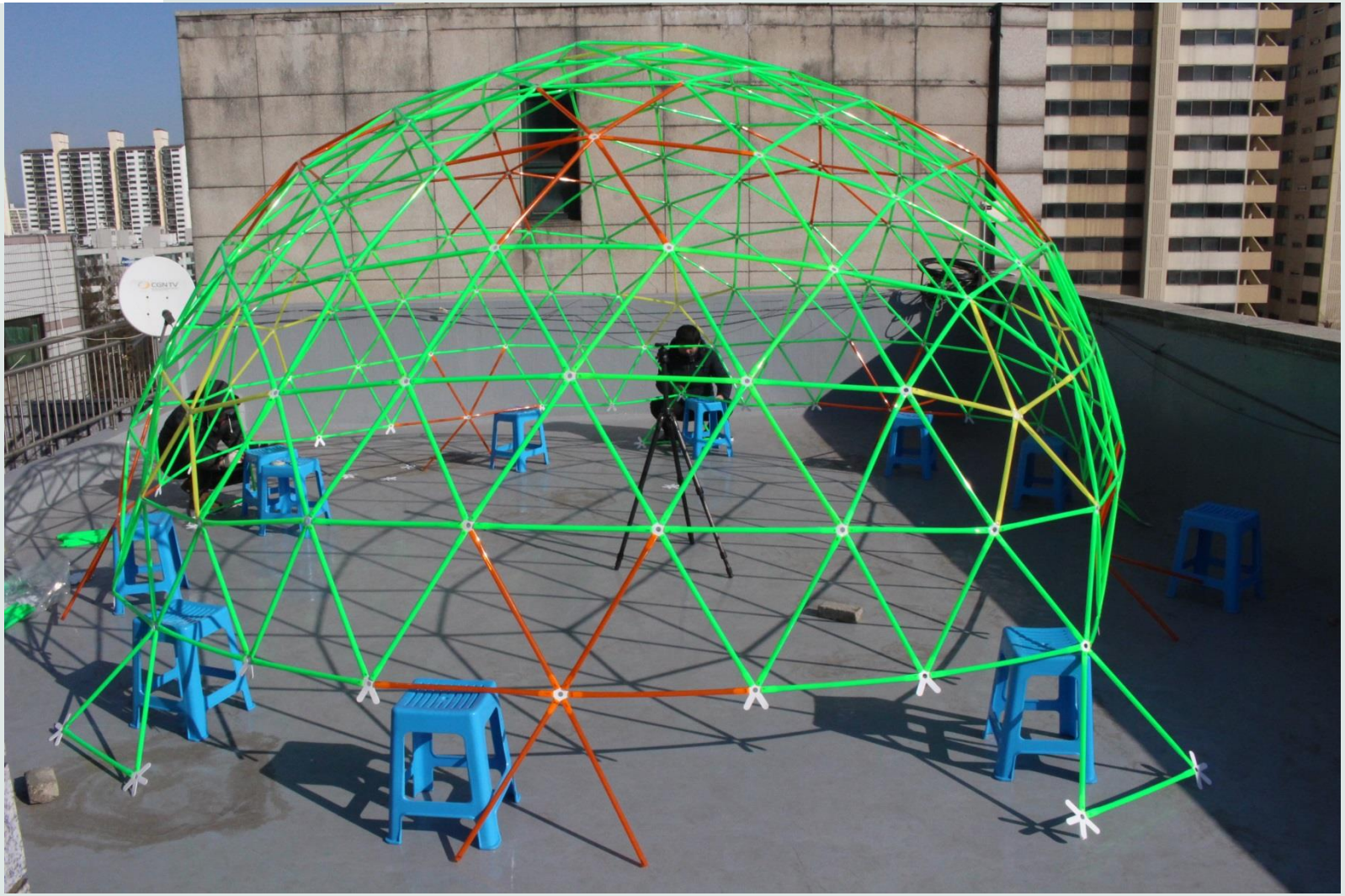

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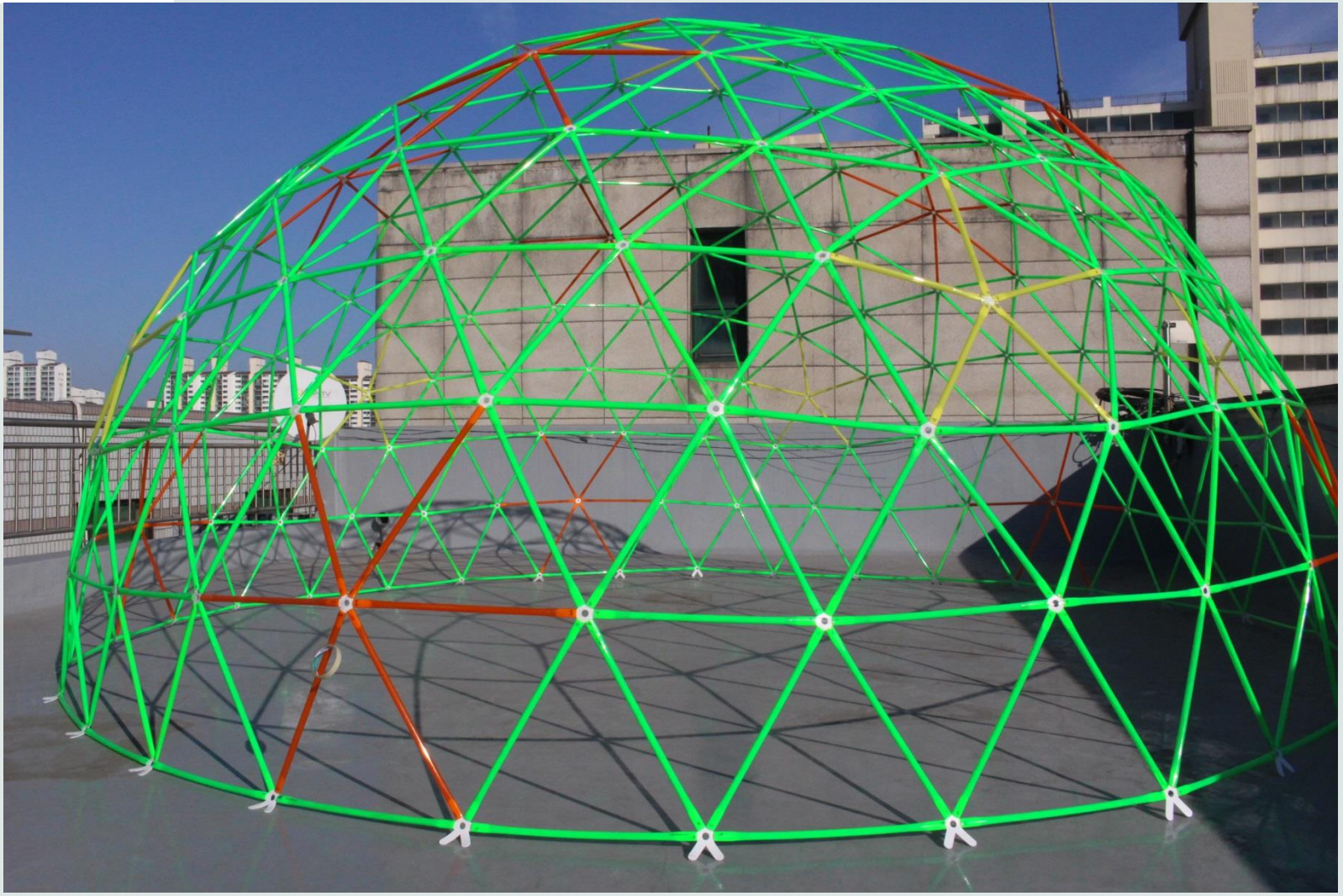

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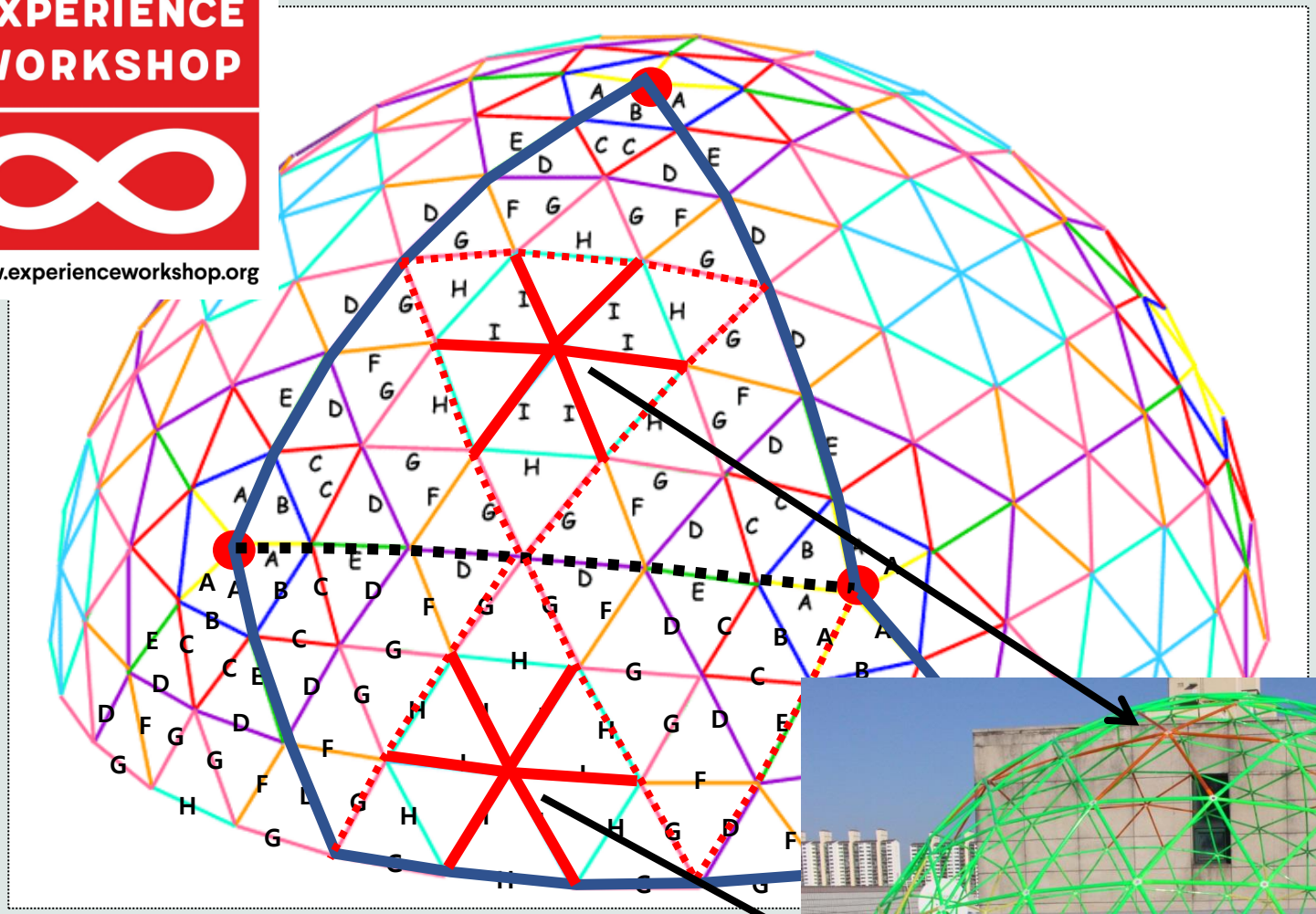

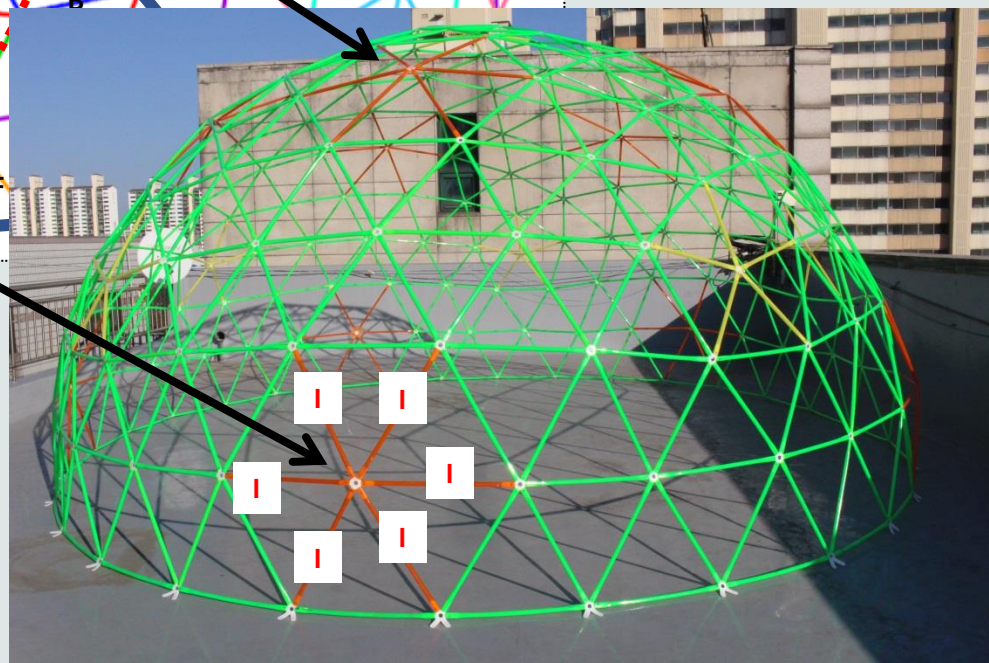

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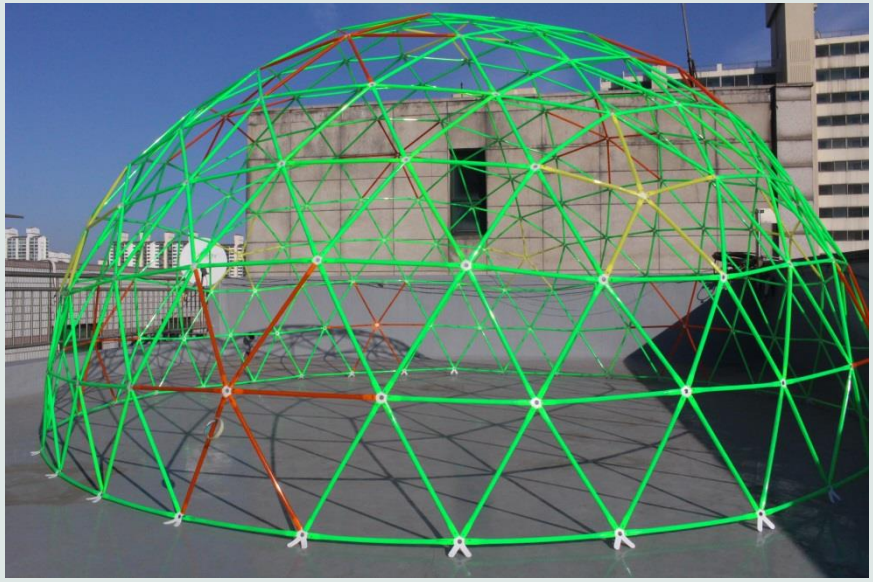
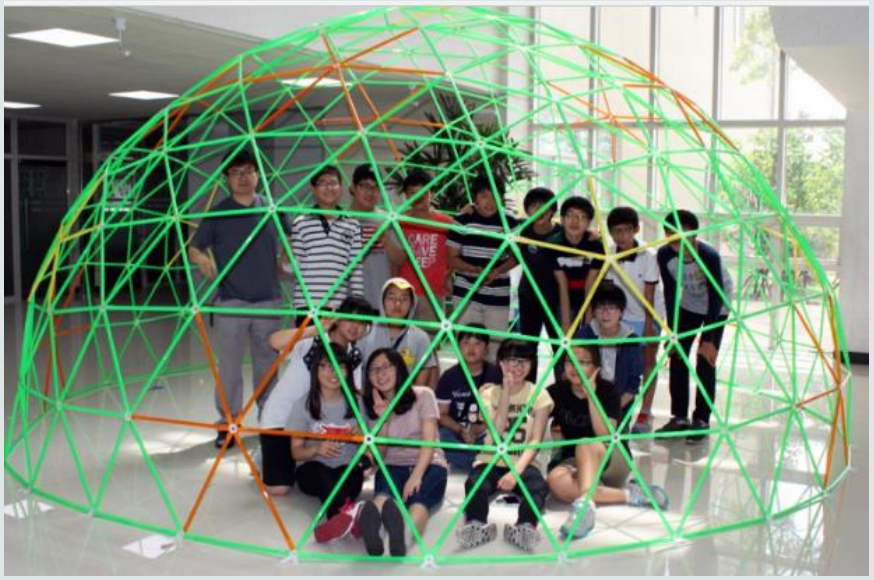
For extra activities inside the dome, open up a small entrance by removing some of the frames.



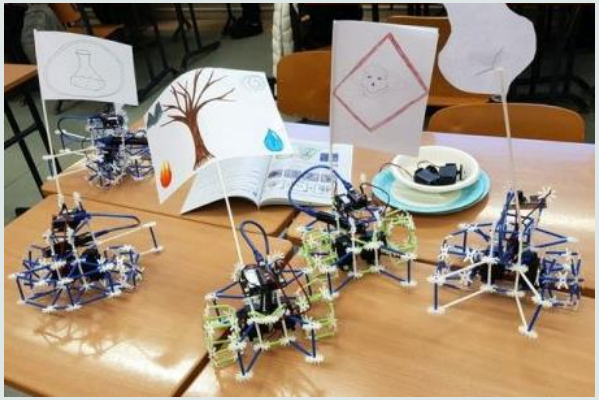


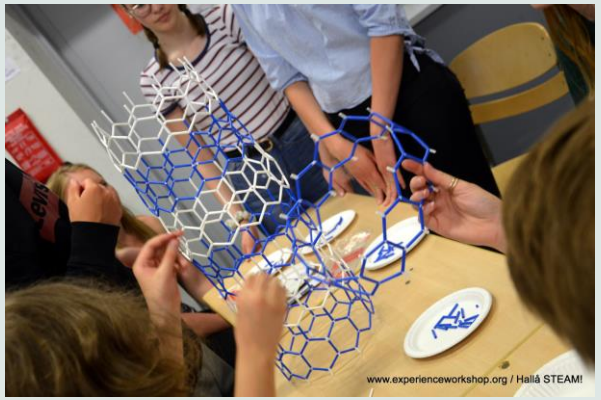
# HALLÅ STEAM!

This educational material was created within the frameworks of the HALLÅ STEAM! program, realized with the support of the **Swedish Cultural Fund** in Finland.

The **Swedish-Finnish STEAM Learning Day "HALLÅ STEAM!"** offers STEAM activities, partially based on historical connections between art and sciences in the Swedish-Finnish context.

The content of the STEAM Learning Day **involves local teachers and students** of the hosting school and is designed in close cooperation with them.






Webpage: https://experienceworkshop.org/halla-steam-svensk-finska-steam-learning-day-2018-2021
The program is realized by **Experience Workshop ay** and supported by the **Swedish Cultural Fund**.

# Experience Workshop

SYNERGIES IN ACTION
Our goal is to offer opportunities for everyone to learn mathematics through the arts, and to create art through mathematics.

NETWORK & EVENTS
We organize creative school days / mathematics & art education programs / multidisciplinary festivals / family days / exhibitions / workshops / seminars and trainings

FULL STEAM AHEAD
We offer research, consultancy and project management in the field of multidisciplinary learning and STEAM (Science, Technology, Engineering, Arts and Mathematics) education.

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Our International Travelling Exhibition of Mathematical Art is ready to visit you. The collection includes artworks, scientific modelling tools, math-art puzzles, and other spectacular objects.


Contact us: info@experienceworkshop.org
Website: www.experienceworkshop.org

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www.learningbydoing.fi







Interested in STEAM? Looking for support in connecting mathematics & art in education? Do you have a good idea?

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