MINI PROJECT
HAWAII GEODESIC DOME

MIHHAIL SAMUSEV
189962
FEM CS1
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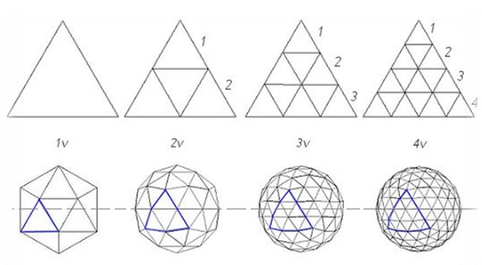
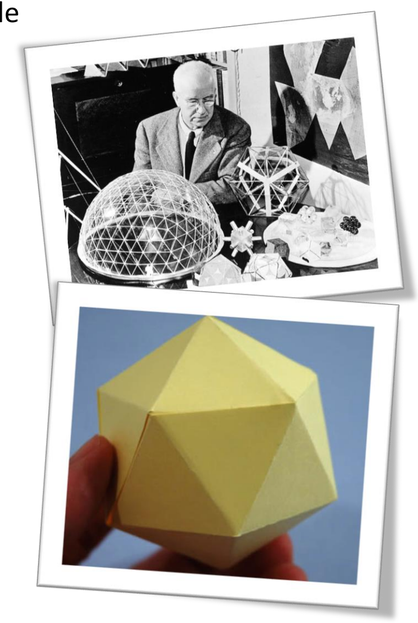
GEOMETRY BACKGROUND

- Buckminster Fuller innovator in architecture and inventor of geodesic dome
- Geodesic dome is the lightest, strongest, and most cost-effective structure known so far by humanity
- Structure is able to cover more space without internal supports than any other enclosure
- Furthermore, it becomes proportionally lighter and stronger the larger it is
- Geometry without corners makes it efficient in heating/cooling/ventilation
- Domes are portable, quick and easy to assemble/dismantle

HOW TO GET A GEODESIC DOME?

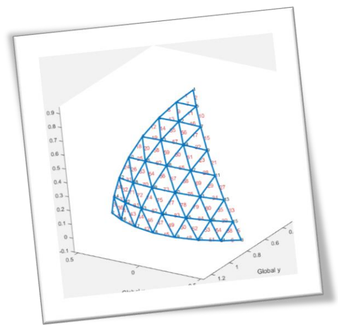
- Take an icosahedron
- Divide each basic triangle according to required frequency
- Bigger frequency = more smooth spherical shape
- Cut in two pieces to get a dome





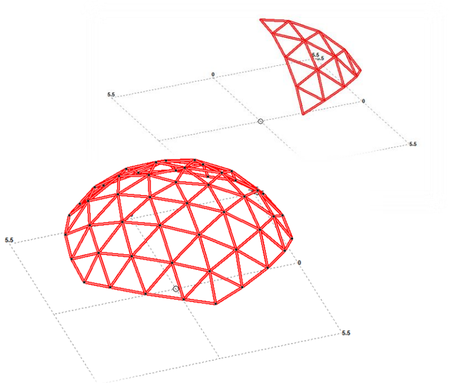
GEOMETRY CONNECTIVITY ARRAY

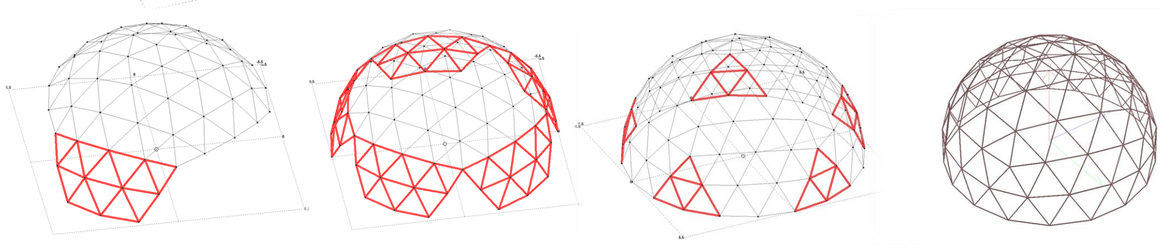
- Lengths of bars are approximately known
- Create a matrix of length between each point
- If length between points fits length of a bar then one of them is a beginning and another is an end
- Avoid repetitions



GEOMETRY TO STAAD

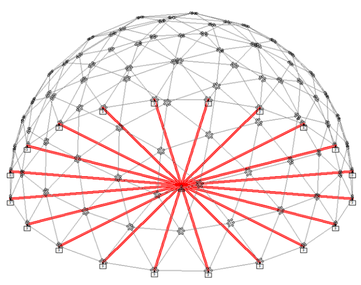
- Coordinates form MATLAB are pasted to STAAD Editor, therefore program builds one spherical triangle automatically
- STAAD.Pro feature such as ”rotational repeat” is then used couple times to revolve and copy initial triangle and finally get the dome

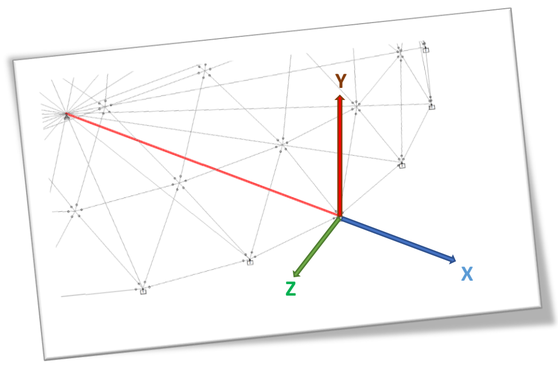




SUPPORTS

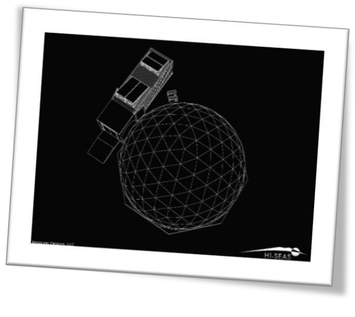
- Flexible supports are used to avoid damages due to thermal expansion
- Neoprene layer simulated by bars with small stiffness (springs)
- Inclined supports (NB! local XYZ):
  - Fx ✖
  - Fy
  - Fz
  - Mx ✖
  - My ✖
  - Mz ✖





CONSTRUCTION - WHERE AND WHY?

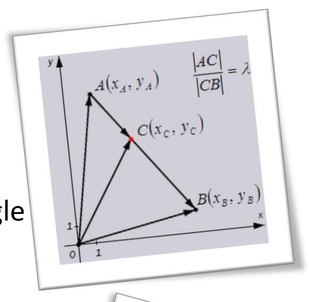
- HI-SEAS - Hawaii Space Exploration Analog and Simulation
- Analogy of Mars environment in Mauna Loa volcano Hawaii
- The purpose of the simulation to determine what is required to keep a space flight crew happy and healthy during an extended mission to Mars and while living on Mars.
- Mission began on 15 October 2014, and includes six crew members.
- The mission is scheduled to end on 12 June 2015
- 2 floor habitat for research crew in form of 11 meter diameter geodesic dome
- Load bearing structure – spherical skeleton performed in steel tubes



GEOMETRY COORDINATE ARRAY

- Get 3 coordinates of any triangle on icosahedron
- Divide sides of triangle depending on desired frequency using school math

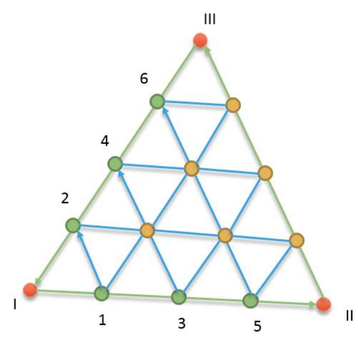
$$x_C = \frac{x_A + \lambda * x_B}{1 + \lambda}$$
$$y_C = \frac{y_A + \lambda * y_B}{1 + \lambda}$$
$$z_C = \frac{z_A + \lambda * z_B}{1 + \lambda}$$

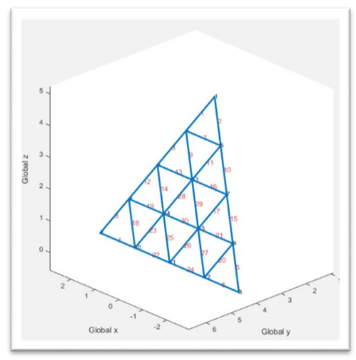


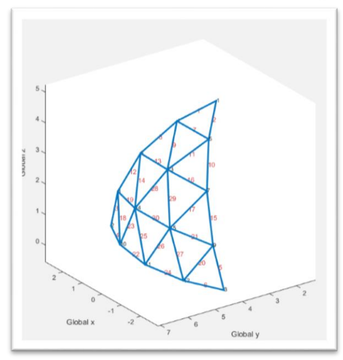
- For easiness create even and odd numbering on opposite sides of triangle
- Add more extra points between even and odd points if frequency is >2

HOW GET IT CURVED?

- Consider icosahedron that can fit into unit sphere
- Trick is to divide all the coordinates by their length (create unit vectors from the origin (0,0,0) to each point)
- Since unit vectors by default have length of 1 all points will be pushed out so that their distance to origin corresponds to 1 unit.

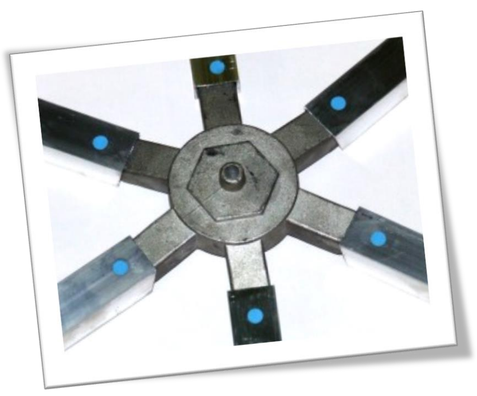






RELEASES

- Hinged joints connecting 6 members
- Members = tension/compression bars
- Releases (local XYZ):
  - Fx
  - Fy
  - Fz
  - Mx
  - My ✖
  - Mz ✖



LOADS AND RESULTS

- Dead load
- Focus on thermal load
  - DS/EN 1991-1-5 Actions on structures – Thermal actions
  - October min record temperature $T_{min} = -3°C$
  - June max record temperature $T_{max} = 22°C$
  - Temperature change $\Delta T = T_{max} - T_{min} = 25°C$