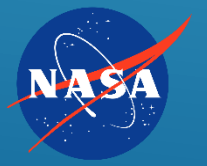
COMPARISON OF COMPUTER ANIMATION METHODS FOR LUNAR SURFACE SOLAR ARRAYS

Luke Cargill

Richard Pappa

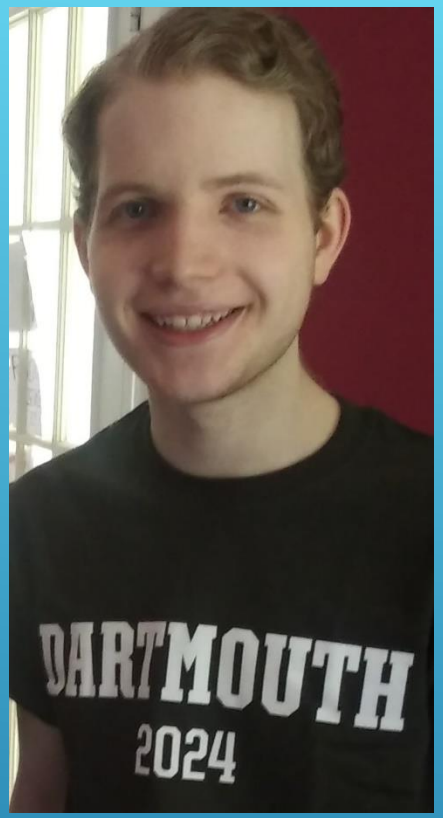
NASA LaRC

Structural Dynamics Branch



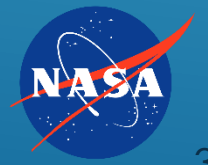
ABOUT LUKE CARGILL

- Smithfield High School & Governor's School for Science and Technology – Class of 2020
- Dartmouth College 2020-2024
- Previous internship experience with Richard Pappa through GSST mentorship program Fall 2019 – Spring 2020

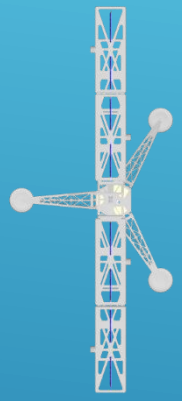


GOAL

Animate deployment of lunar solar array model and compare capabilities of various software

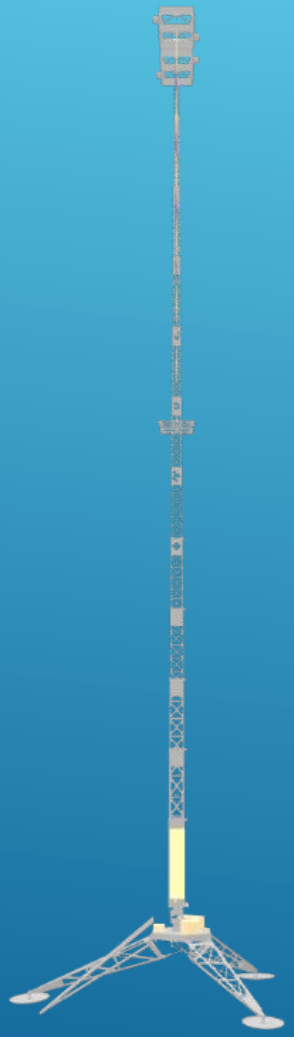


Model created by Scott Belbin

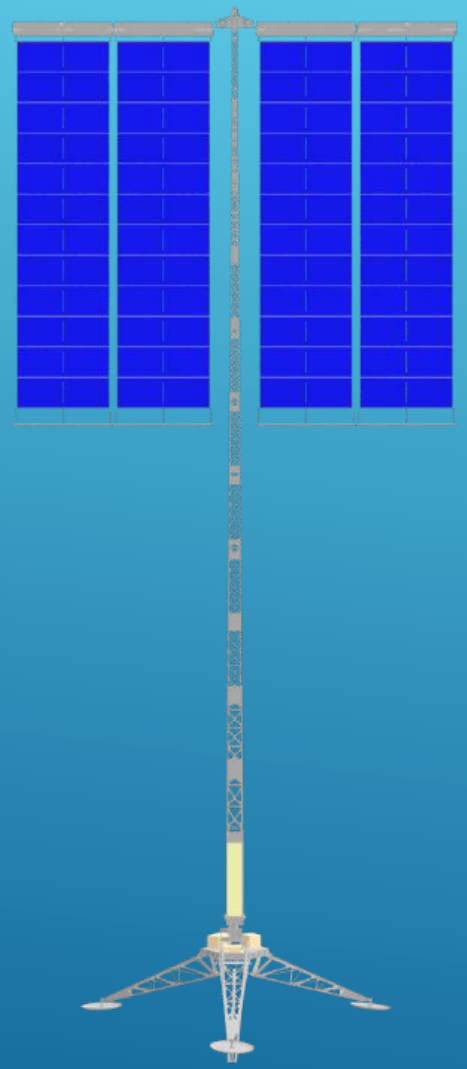


Top

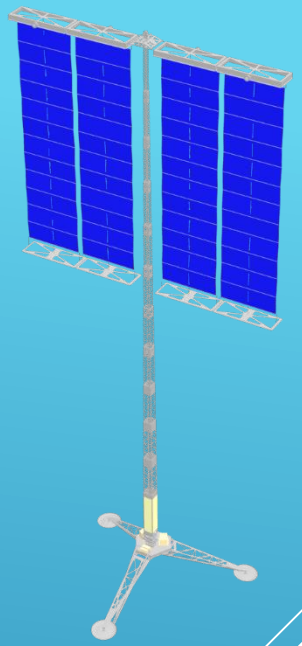
Bottom



Side



Front

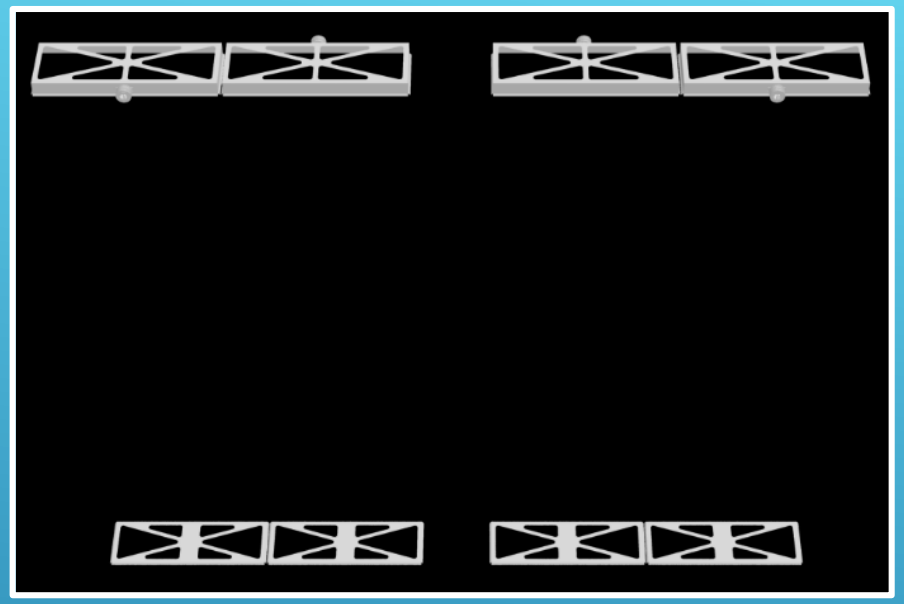


MODEL OVERVIEW

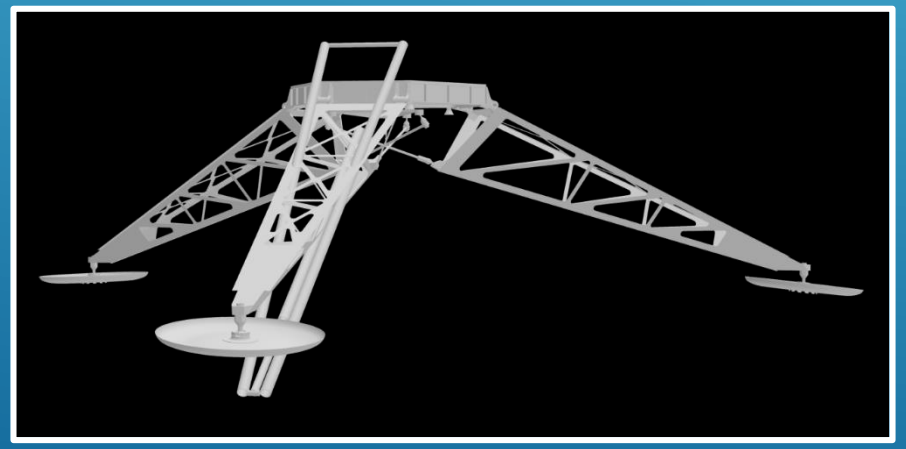
LSSA V2

- Four 1.5 m wide Arrays
- Four Housings
- Twelve Panels per Housing
- Twelve Mast Segments
- Three Leg Stand

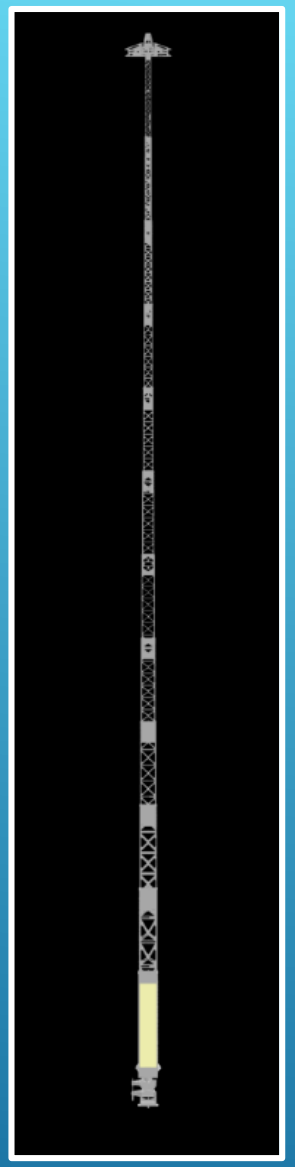
12,710,866 Triangles



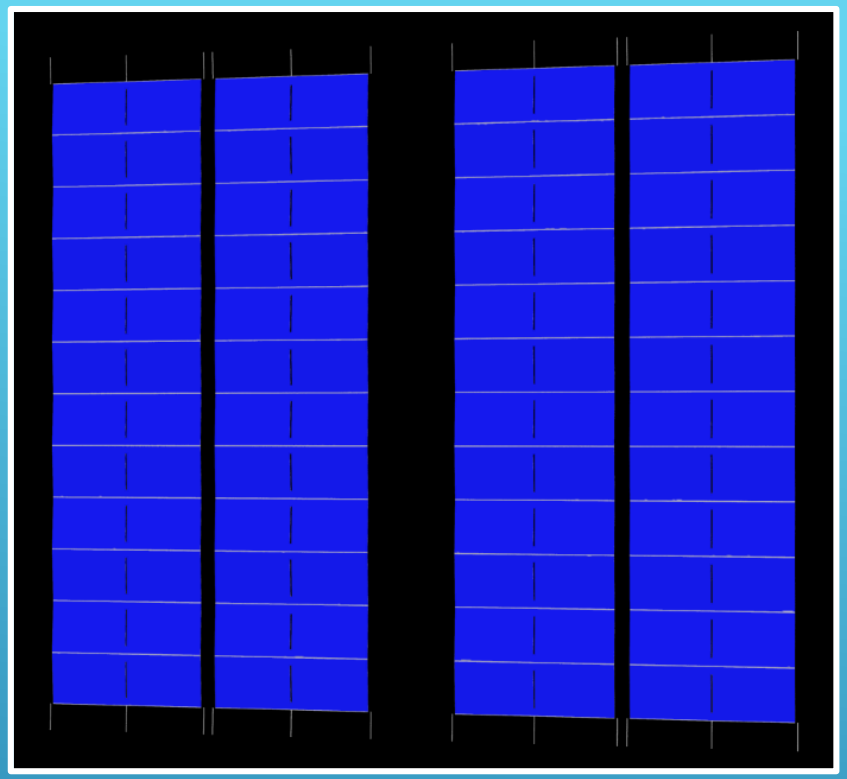
Housings



Legs



Mast



Panels

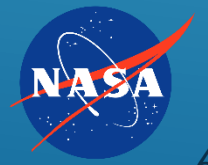
A CLOSER LOOK

SOFTWARE

KeyShot

Blender

Maya

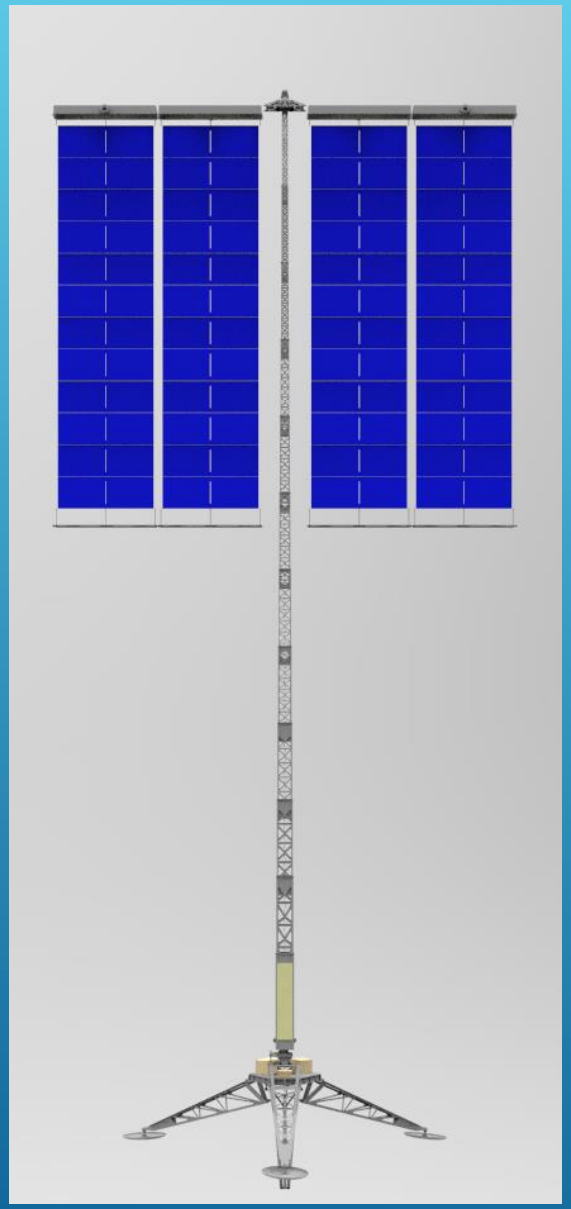


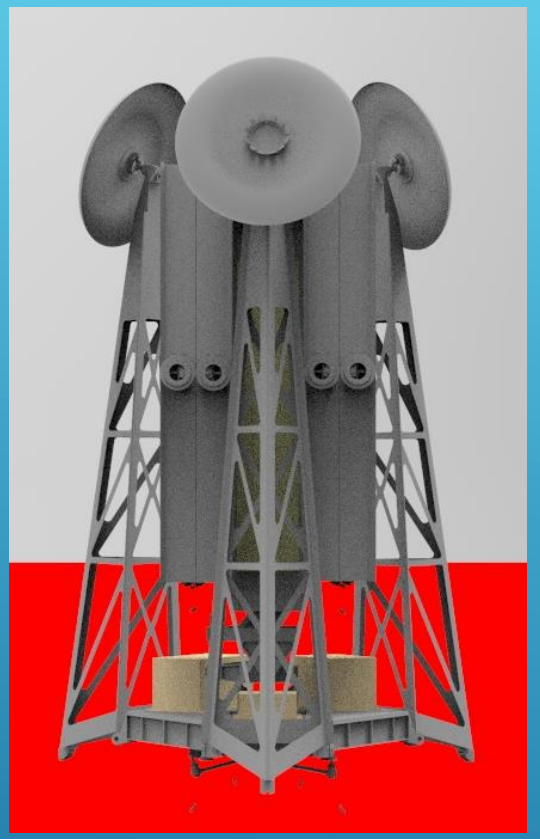
KEYSHOT ANIMATION METHODS

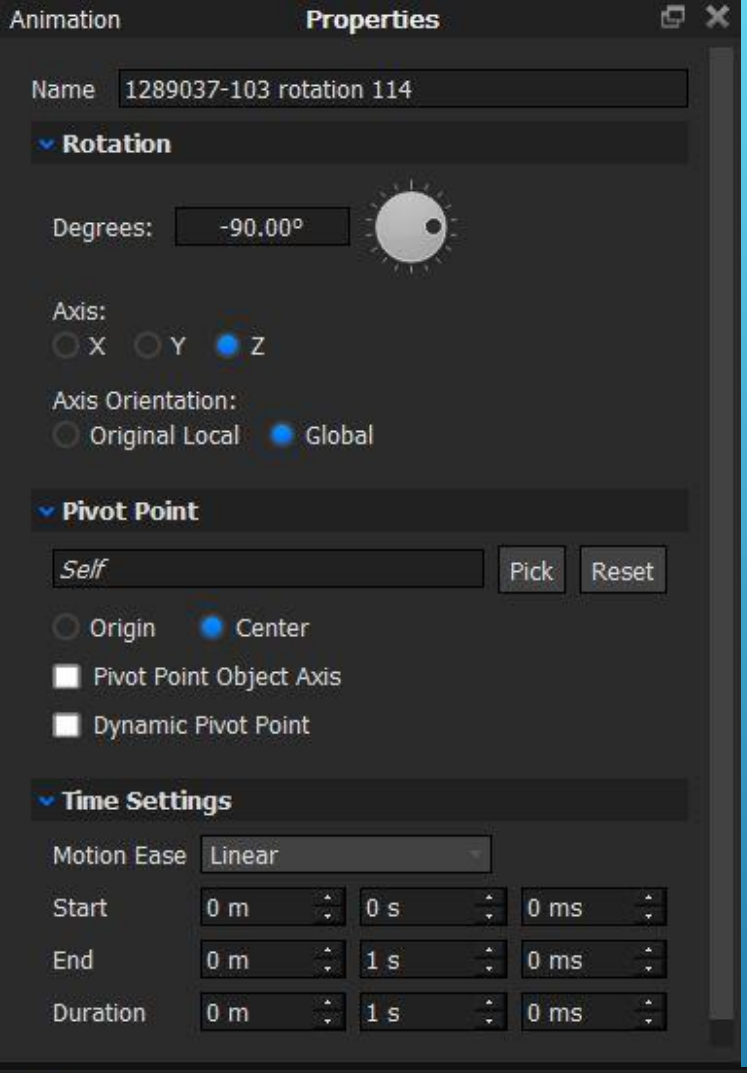
GENERAL ANIMATION NOTES

- To Add Animation, right click item in scene tree
- Select animation type (rotation, translation, turntable, fade)
- Green bar representing the animation will appear in Animation Wizard Menu
- Green animation bars appear in the order that they were added
- All objects share the same animation menu
- Adjust time and value (i.e. distance, degrees) of animation in properties, or
  - Adjust the time duration by clicking and dragging an edge of a green animation bar
  - Click in the middle of a green animation bar and move it to start at a different time stamp
- All animations applied to a group are applied to every item in the group

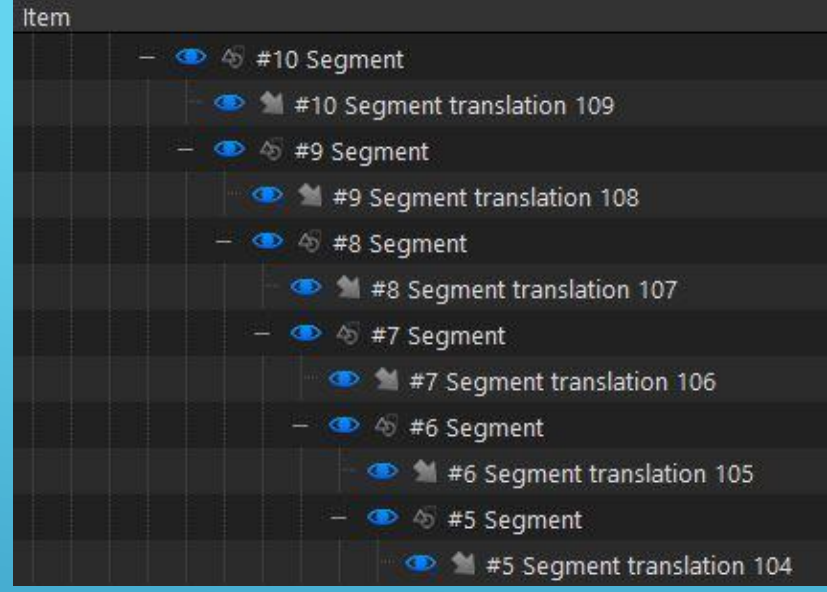
Note: Imported animations appear as purple bars in the Animation Wizard Menu



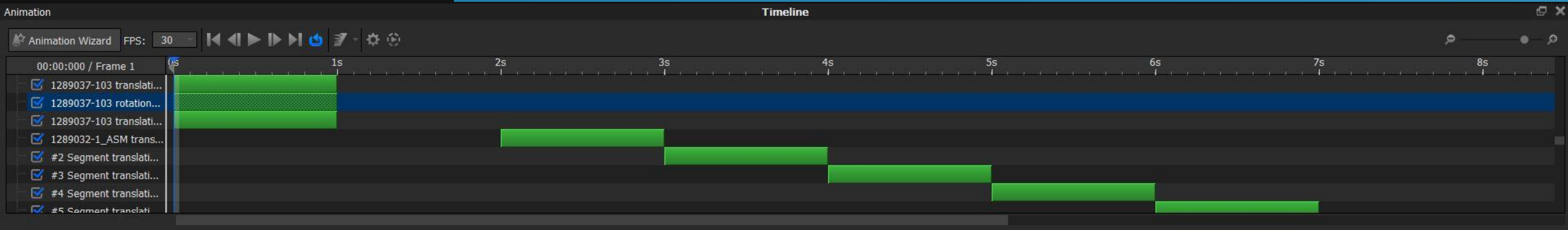




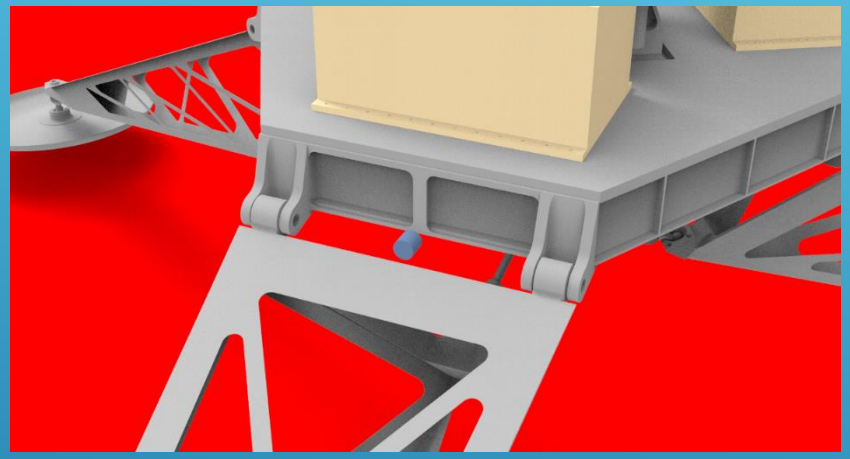
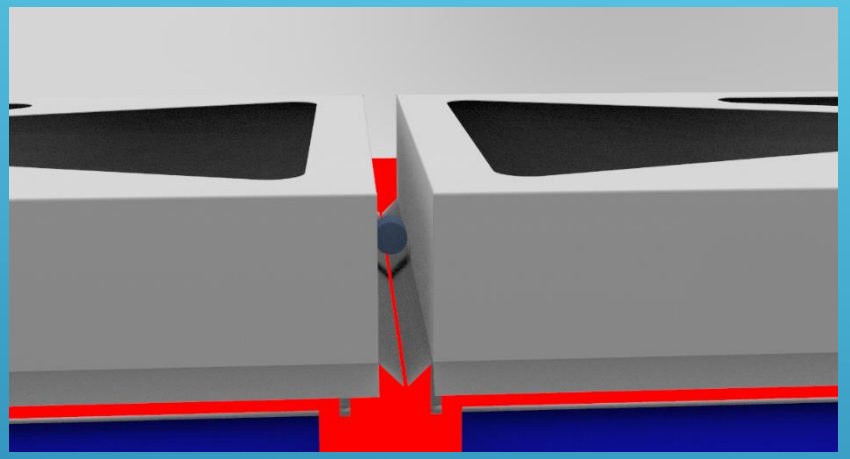
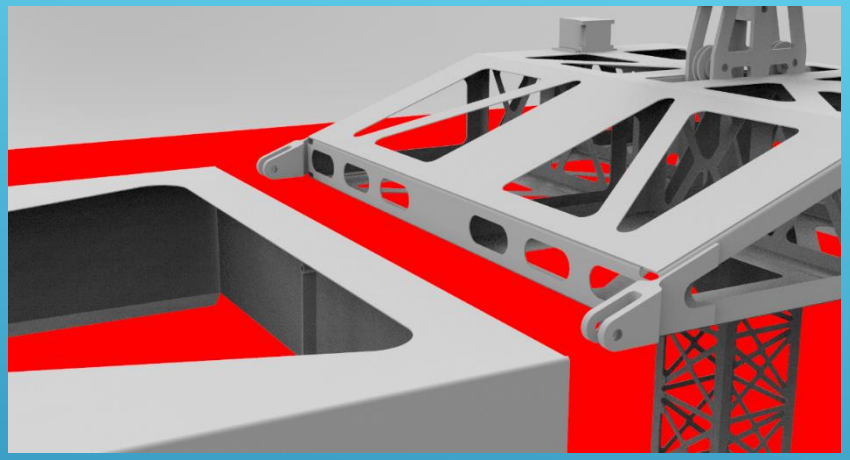
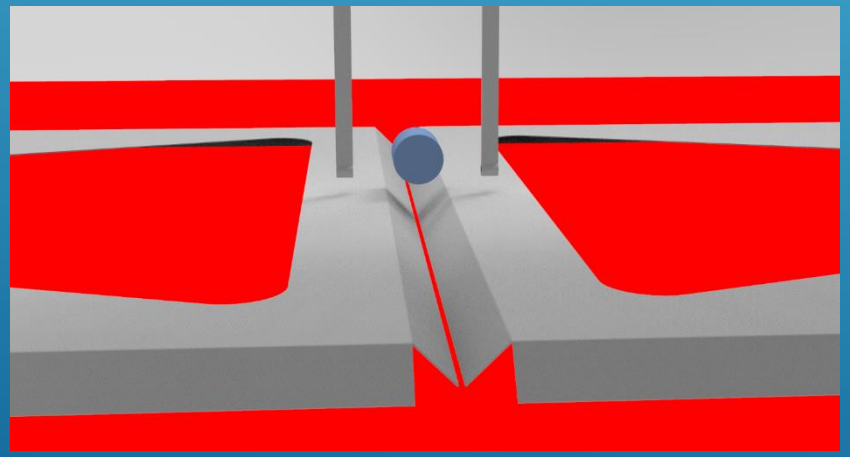
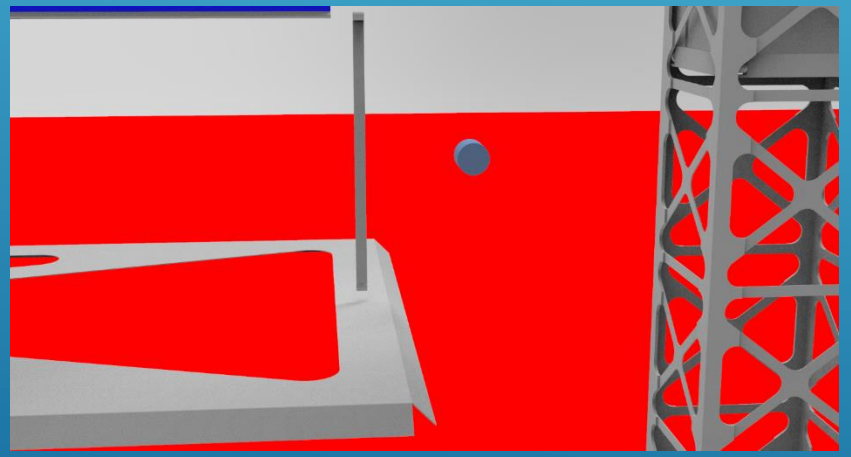
- Legs:
  - pivot objects created using “add geometry” > “cylinder”
  - pivots placed between base of mast and top of leg
  - rotated each leg around pivot object up 115 deg. according to its local axis
- Panels:
  - every odd/even panel rotated about self 90 deg./-90 deg.
- Housings:
  - pivot objects created using “add geometry” > “cylinder”
  - pivots placed between top of mast and inside edge of housing

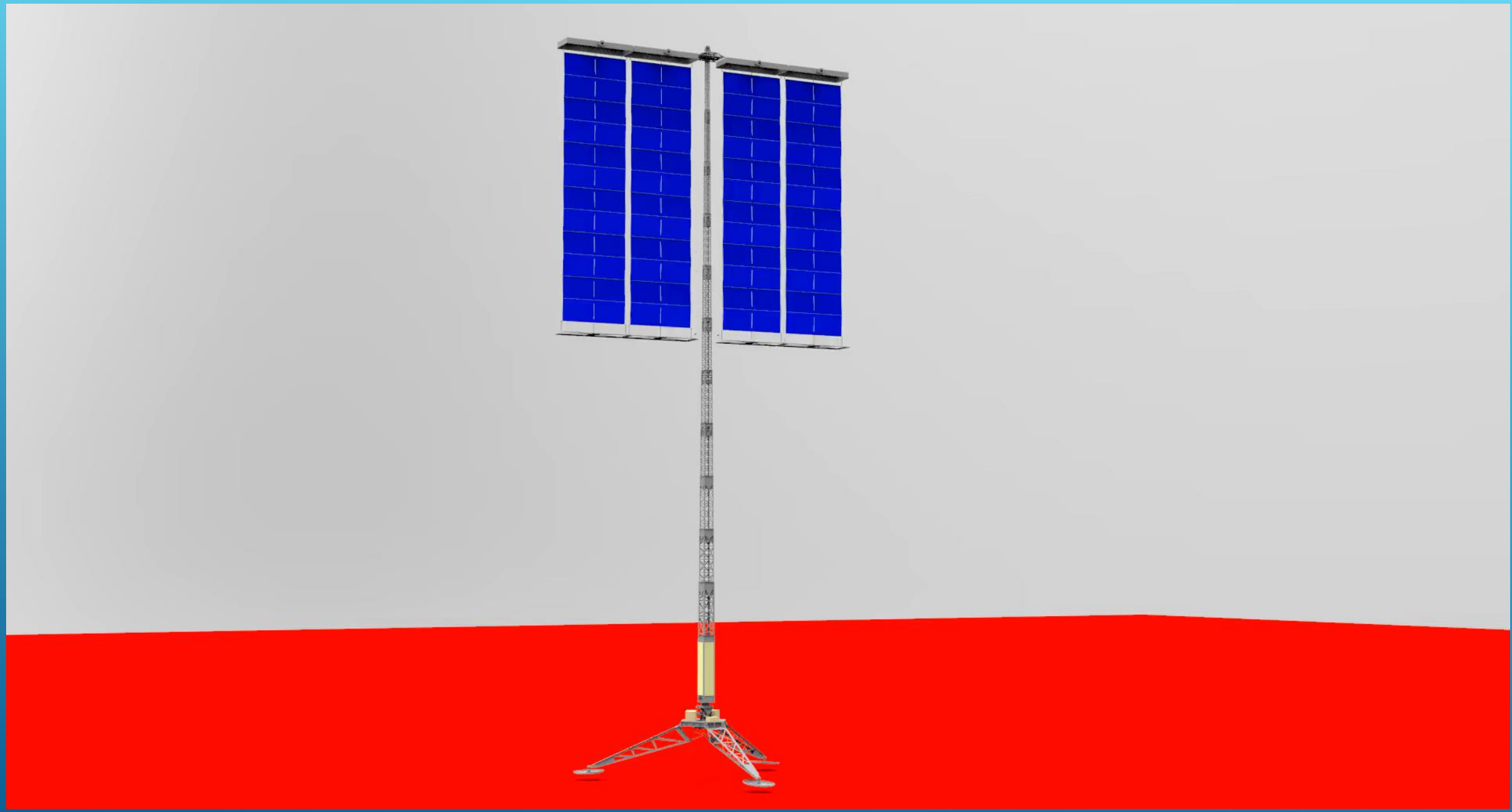


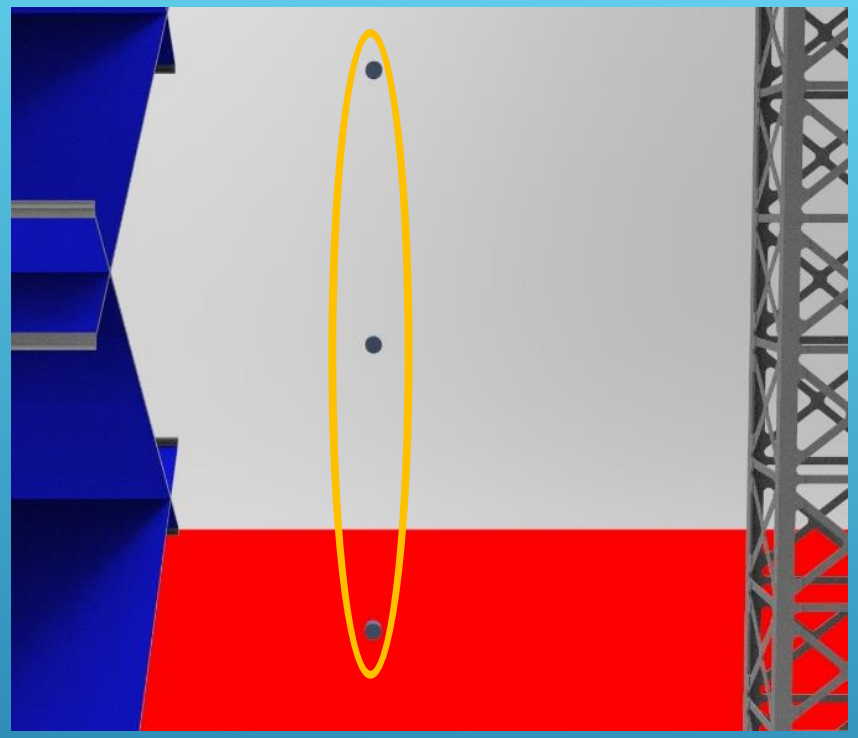
- Mast: Each segment grouped to include self and every segment above it



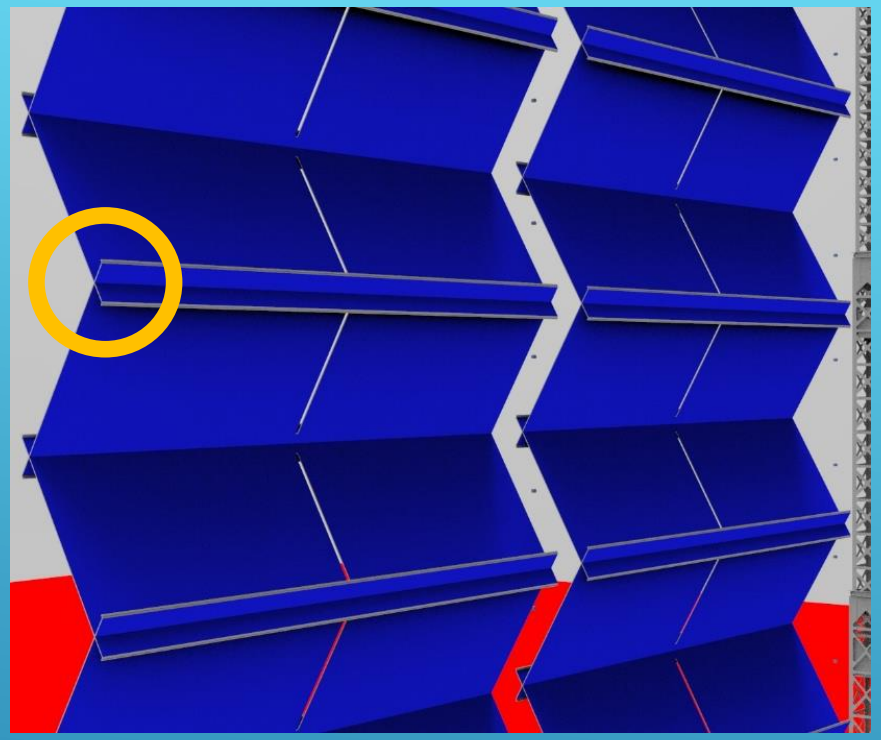
Pivots

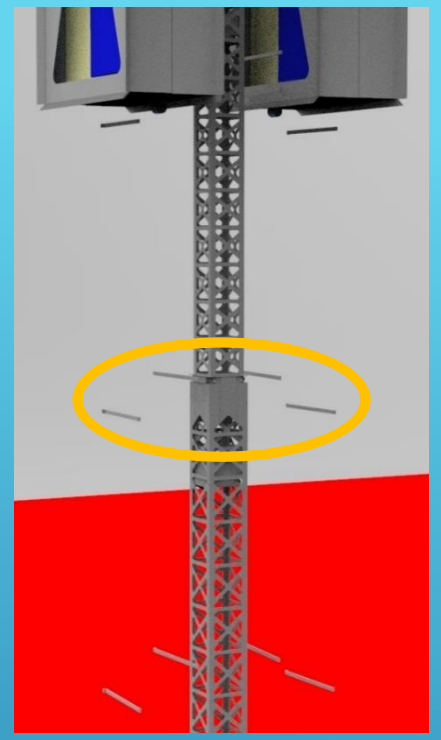




- Pivot objects visible
- Difficult to position
- Unrealistic positions



- Panels clip each other
- Adjusting time creates too much distance between panels



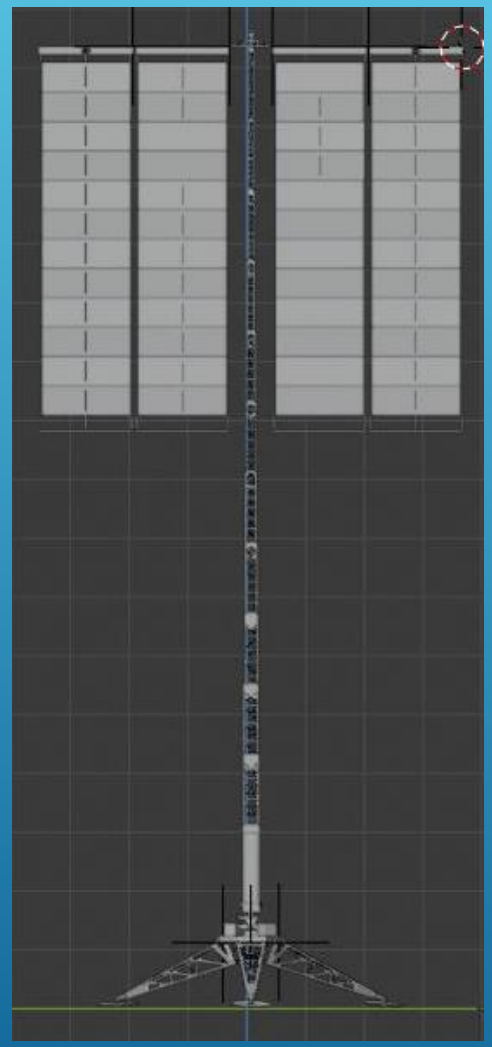
- New pivots needed for hinges regardless of grouping
- Pivot object clutter
- Time consuming

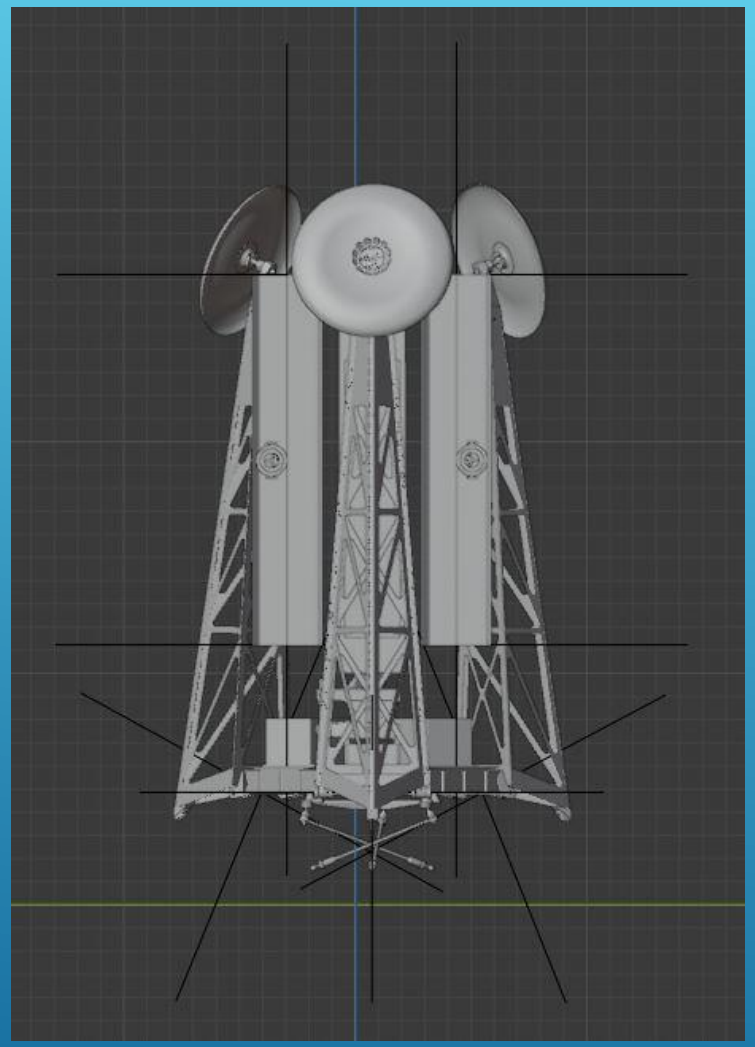
BLENDER ANIMATION METHODS

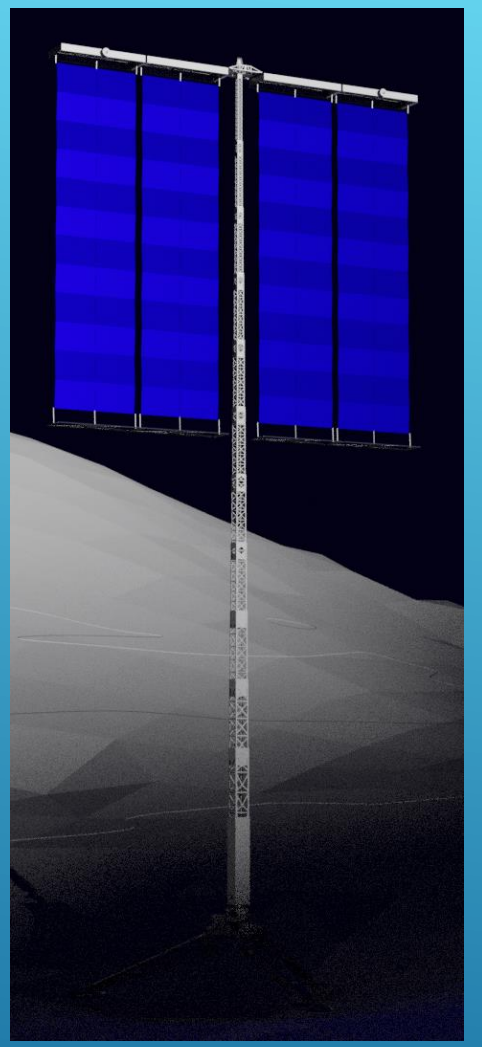
GENERAL ANIMATION NOTES

- Solid View mode is best for animation (as opposed to Render View mode)
- Insert a key frame at a location
- Move the part
- Insert a frame at the new location
- Adjust the interpolation mode (e.g. linear, exponential, constant) to change the acceleration of the auto-keying between frames

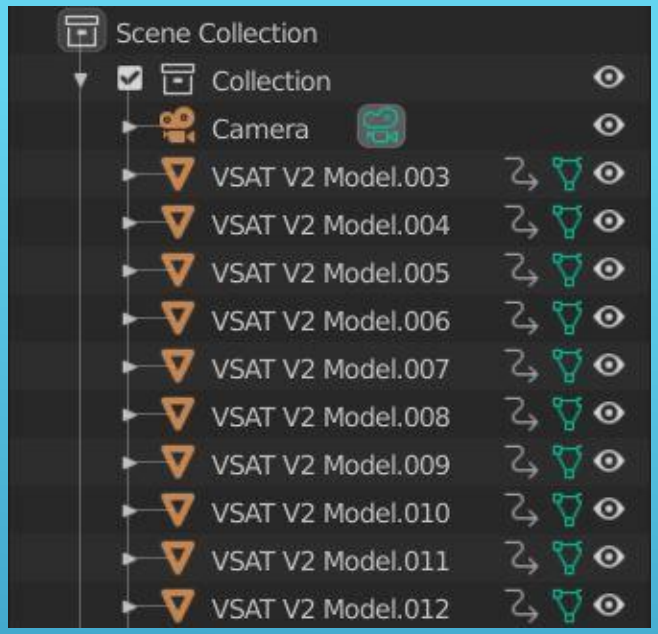
Note: a yellow bar will appear between key frames if nothing changes between or at those frames



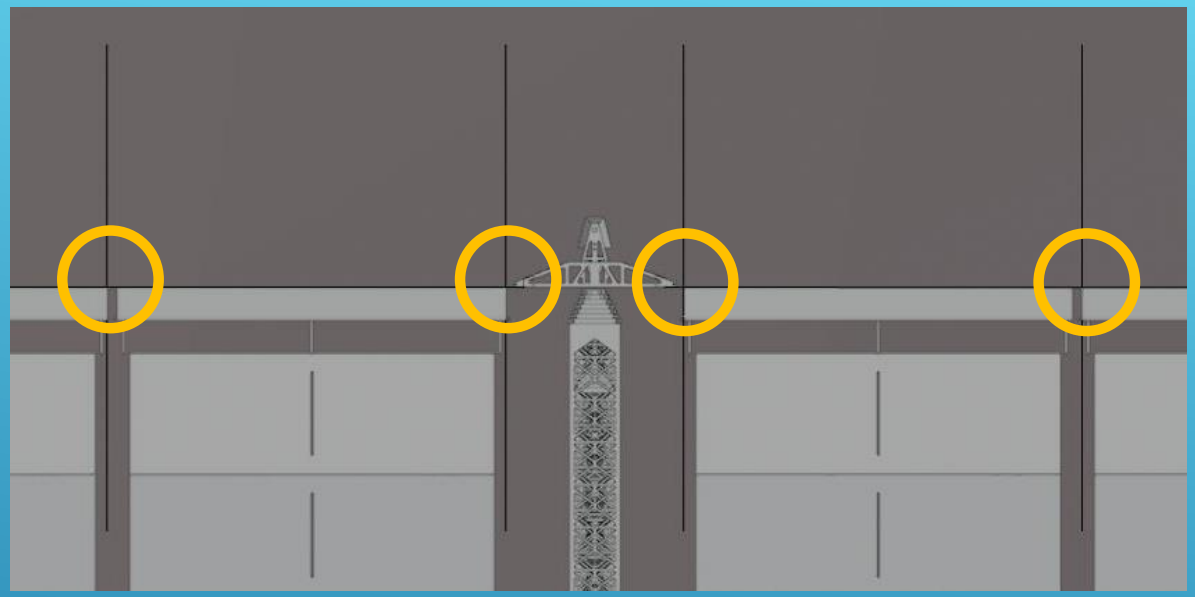


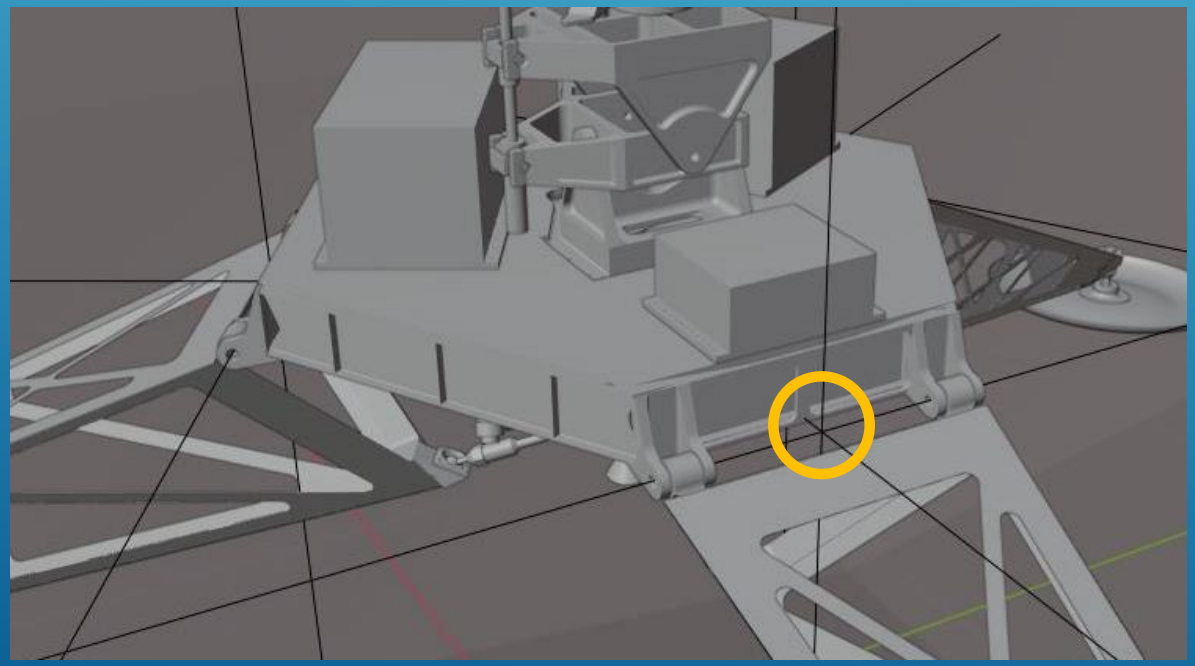


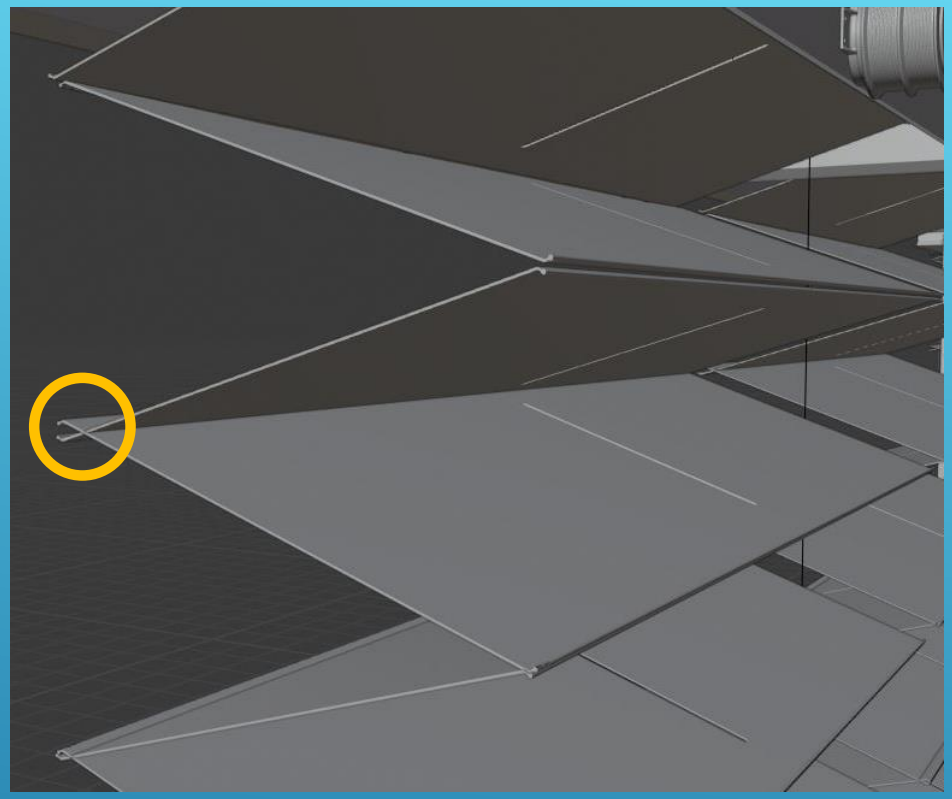
- Housings:
  - empty (pivot) objects created using “Add” > “Empty”>”Plain Axes
  - empties placed between top of mast and inside edge of housing
- Panels:
  - placed 3D cursor at midpoint of the top edge of the panel
  - set origin for each panel to 3D cursor at that point
  - every odd/even panel rotated about self 90 deg./-90 deg.
- Mast:
  - each segment collection parents the group of segments below it to create a telescoping deployment method
- Legs:
  - empty (pivot) objects created using “Add” > “Empty”>”Plain Axes
  - empties placed between base of mast and top of leg
  - rotated each leg around empty up 115 deg. according to its local axis

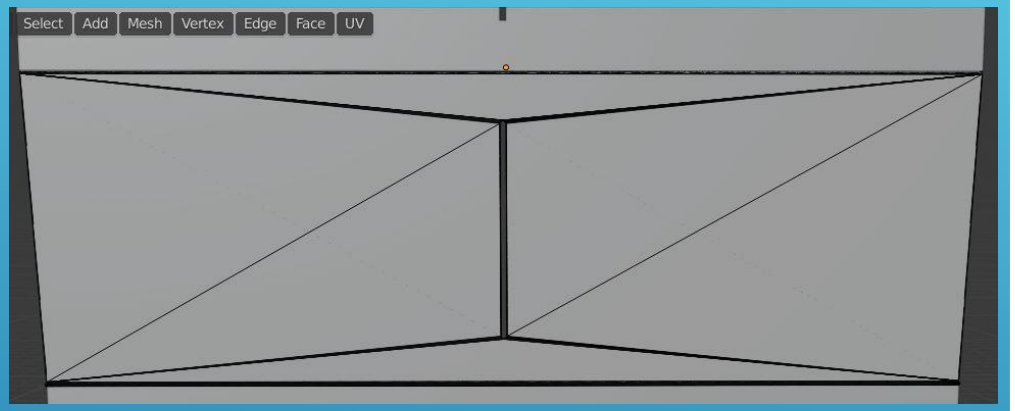


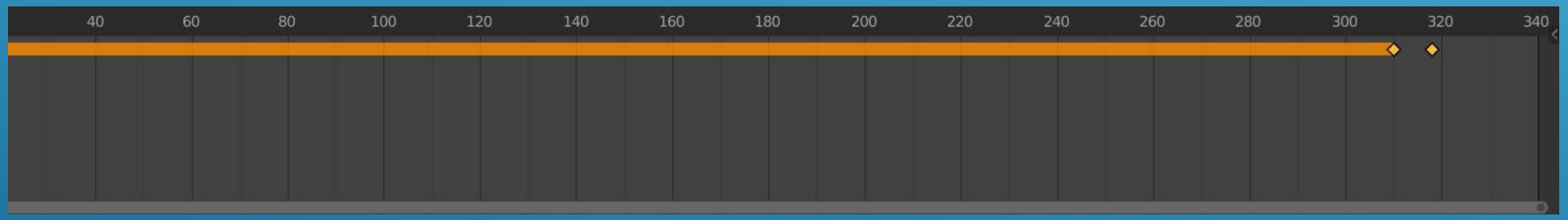
Pivots









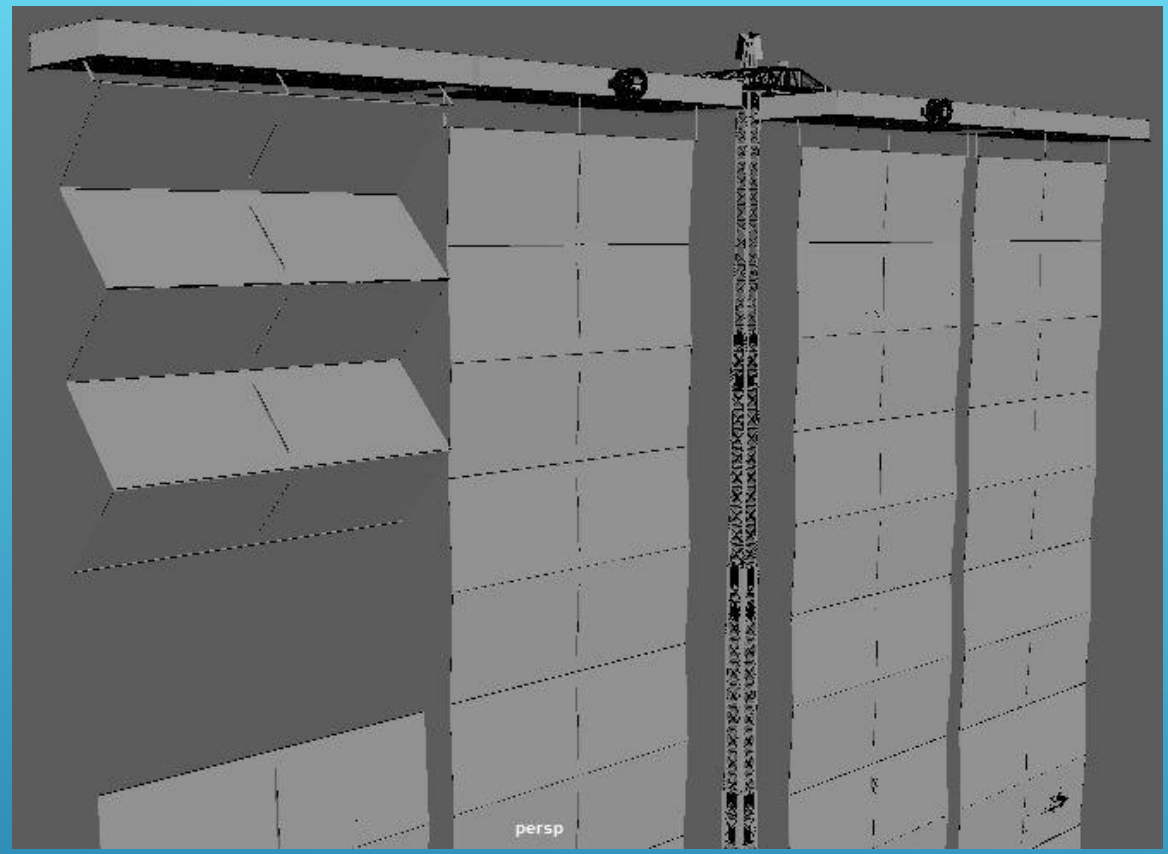


- Panel origin positioning imprecise
- Slight separation between some panels
- Incorrect hinge animation

- Moon shifts despite no key frames apparent on timeline
- All possible parent constraints cleared
- Counter animation inserted to avoid movement

MAYA ANIMATION PLANS

- Very capable of solar array animation
- Intricate display of features
- Cross between KeyShot and Blender:
  - heavy usage of grouping like in KeyShot
  - key frame based animation like in Blender
- Image shows array partially animated
- Hinges made parent objects of top panels



CONCLUSION

Blender is best

1.) Easy to learn

2.) Massive Animation Toolset

3.) Free

KeyShot

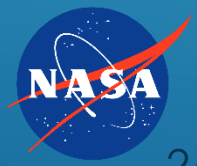
Blender

Maya

Thank you, Mr. Pappa!

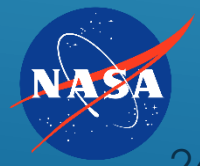
ACKNOWLEDGEMENTS

QUESTIONS



ADDITIONAL INFORMATION

VARIATIONS



USER INTERFACE COMPARISON

KeyShot 8.2 Pro Floating License - untitled.bip - 64 bit

File Edit Environment Lighting Camera Image Render View Window Help

Default | 100 % | Workspaces | CPU Usage | Pause | Performance Mode | Render NURBS | Region | Move Tool | Tumble | Pan | Dolly | 50.0 | Perspective | Add Camera | Cycle Cameras | Reset Camera | Lock Camera | Add Studio | Cycle Studios | Studios | Material Templates | Geometry View | Configurator Wizard

Library **Materials**

Mater... Colors Textu... Envir... Backp... Favor...

Downloads
- Materials
  - Architectural
  - Axalta Paint
  - Cloth and Leather
  - Cutaway
  - Gem Stones
  - Glass
  - Liquids
  - Measured
  - Metal
  - Miscellaneous

A Little Lila... Amazing Gr... Amazon M...
Blackberry Br... Blazing Copp... Blue By-Y...
Bombay Bl... Brick House_... Cappuccino...
Catalina Dre... Champan... Cherry Bom...

FPS: 9.2
Time: 1s
Samples: 17
Triangles: 0
Res: 1156 x 619
Focal Length: 50.0

KEYSHOT

Project **Scene**

Scene Material Environ... Lighting Camera Image

Show | Search All

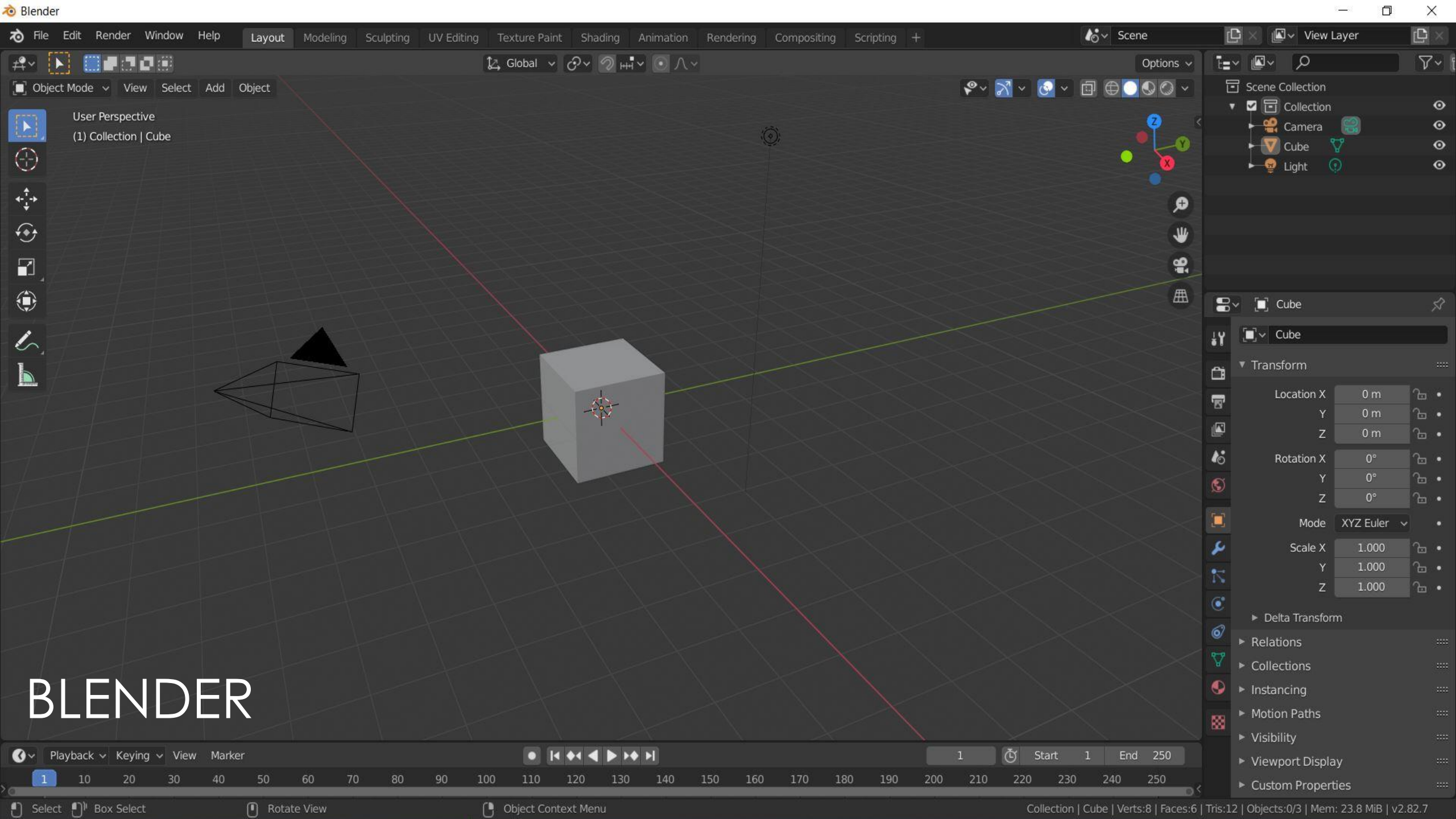
Item	Detail
Model Sets	-
Cameras	
Free Camera	-

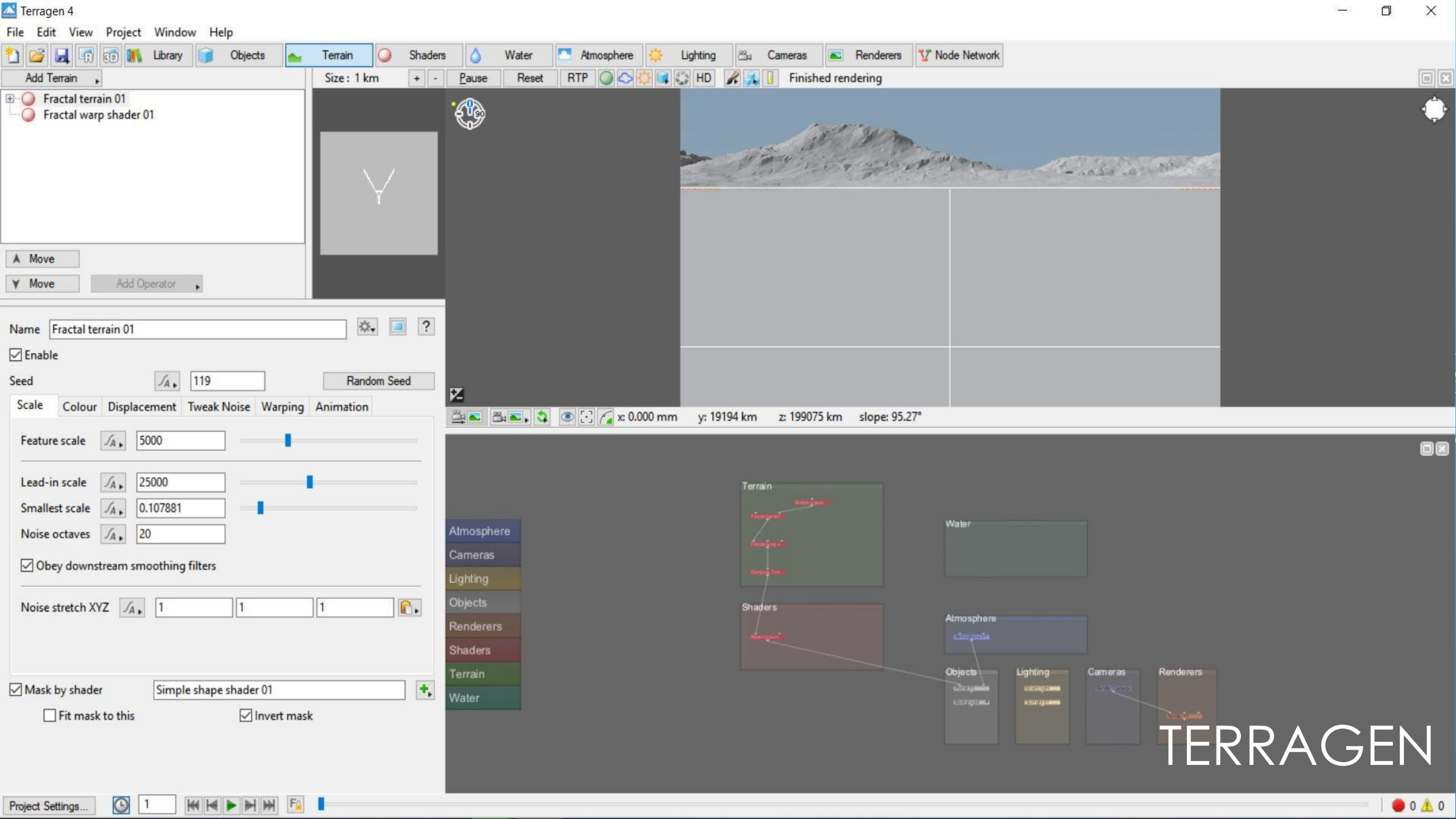
Scene Materials

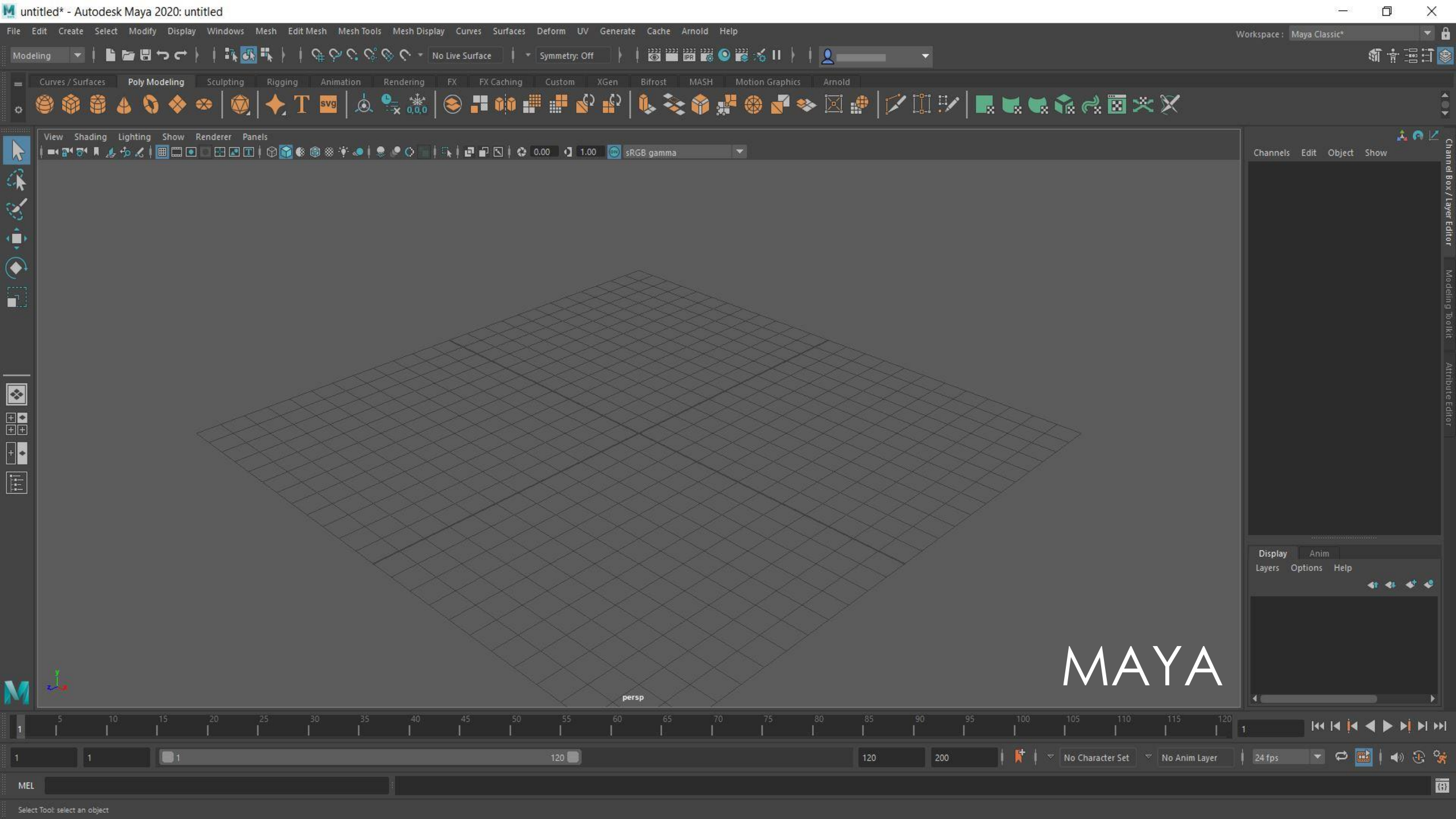
Scene Information

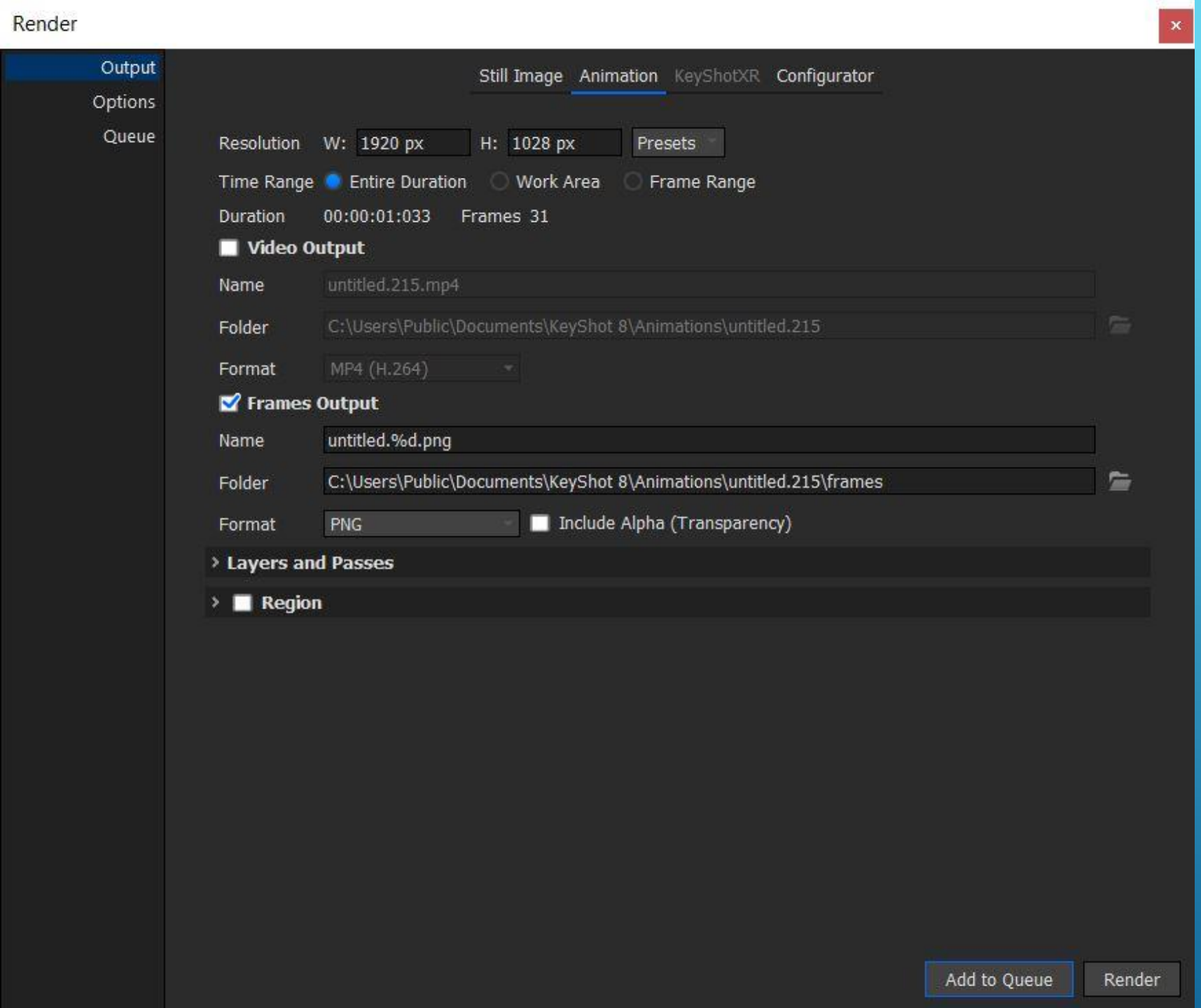
Name:
Units: Unknown
Model Sets: 1

Cloud Library | Import | Library | Project | Animation | KeyShotXR | Render | Screenshot


Blender
File Edit Render Window Help
Layout Modeling Sculpting UV Editing Texture Paint Shading Animation Rendering Compositing Scripting
Scene
View Layer
Global
Options
Object Mode View Select Add Object
User Perspective
(1) Collection | Cube
Scene Collection
Collection
Camera
Cube
Light
Cube
Cube
Transform
Location X 0 m
Y 0 m
Z 0 m
Rotation X 0°
Y 0°
Z 0°
Mode XYZ Euler
Scale X 1.000
Y 1.000
Z 1.000
Delta Transform
Relations
Collections
Instancing
Motion Paths
Visibility
Viewport Display
Custom Properties
BLENDER
Playback Keying View Marker
1
Start 1
End 250
1 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250
Select
Box Select
Rotate View
Object Context Menu
Collection | Cube | Verts:8 | Faces:6 | Tris:12 | Objects:0/3 | Mem: 23.8 MiB | v2.82.7


Terragen 4
File Edit View Project Window Help
Library Objects Terrain Shaders Water Atmosphere Lighting Cameras Renderers Node Network
Add Terrain
Fractal terrain 01
Fractal warp shader 01
Move
Move
Add Operator
Size : 1 km
Pause Reset RTP HD
Finished rendering
x: 0.000 mm y: 19194 km z: 199075 km slope: 95.27°
Name Fractal terrain 01
Enable
Seed 119 Random Seed
Scale Colour Displacement Tweak Noise Warping Animation
Feature scale 5000
Lead-in scale 25000
Smallest scale 0.107881
Noise octaves 20
Obey downstream smoothing filters
Noise stretch XYZ 1 1 1
Mask by shader Simple shape shader 01
Fit mask to this
Invert mask
Atmosphere
Cameras
Lighting
Objects
Renderers
Shaders
Terrain
Water
TERRAGEN
Project Settings...

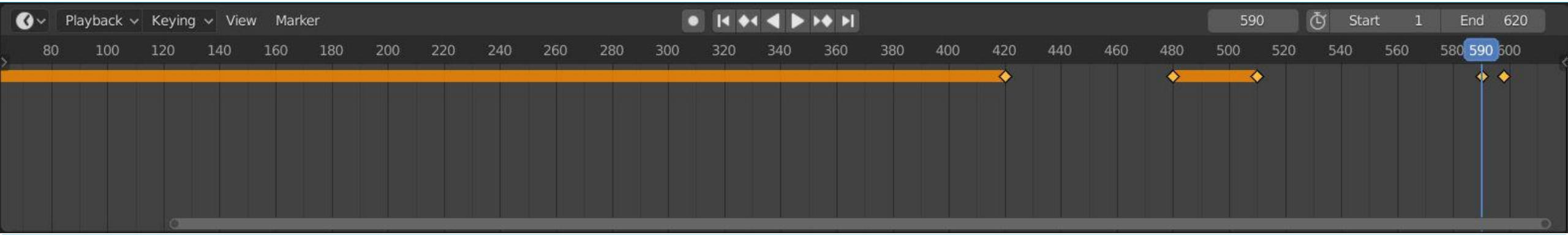

untitled* - Autodesk Maya 2020: untitled
File Edit Create Select Modify Display Windows Mesh Edit Mesh Mesh Tools Mesh Display Curves Surfaces Deform UV Generate Cache Arnold Help
Workspace : Maya Classic*
Modeling
No Live Surface
Symmetry: Off
Curves / Surfaces Poly Modeling Sculpting Rigging Animation Rendering FX FX Caching Custom XGen Bifrost MASH Motion Graphics Arnold
View Shading Lighting Show Renderer Panels
sRGB gamma
Channels Edit Object Show
Display Anim
Layers Options Help
persp
MAYA
MEL
No Character Set
No Anim Layer
24 fps
Select Tool: select an object



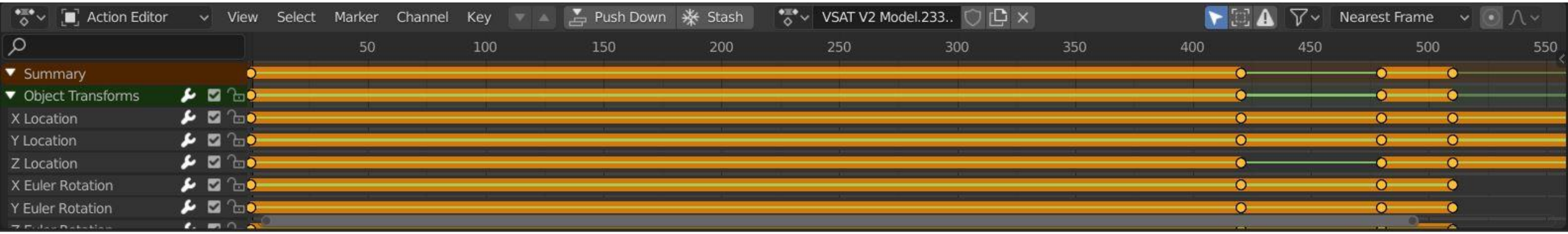
1. Render Settings
2. Animation
3. Frames Output
4. Folder
5. Render

*Use a video sequencer to piece together frames in desired order

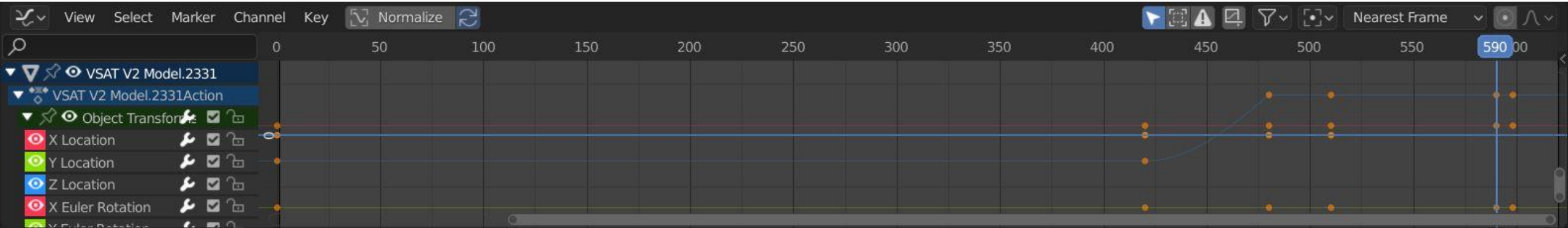
Timeline

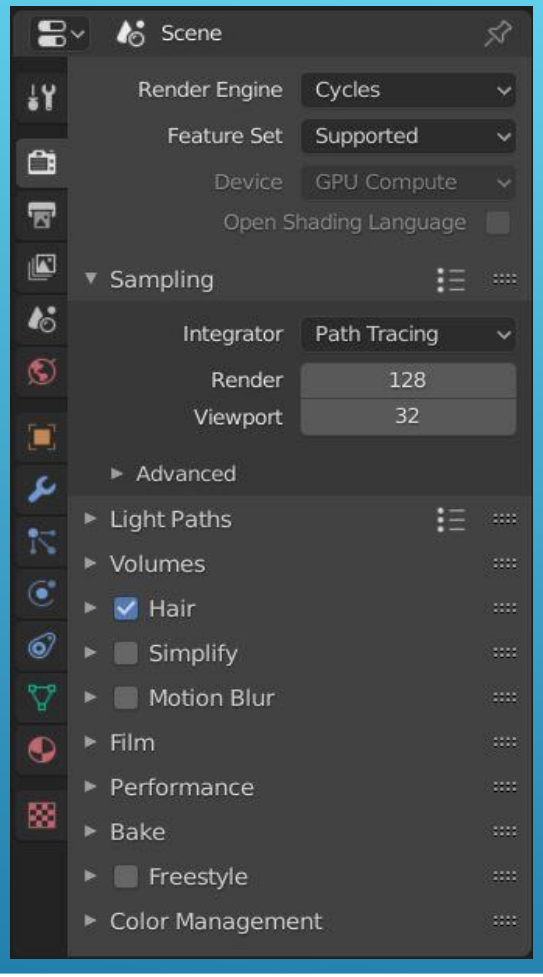


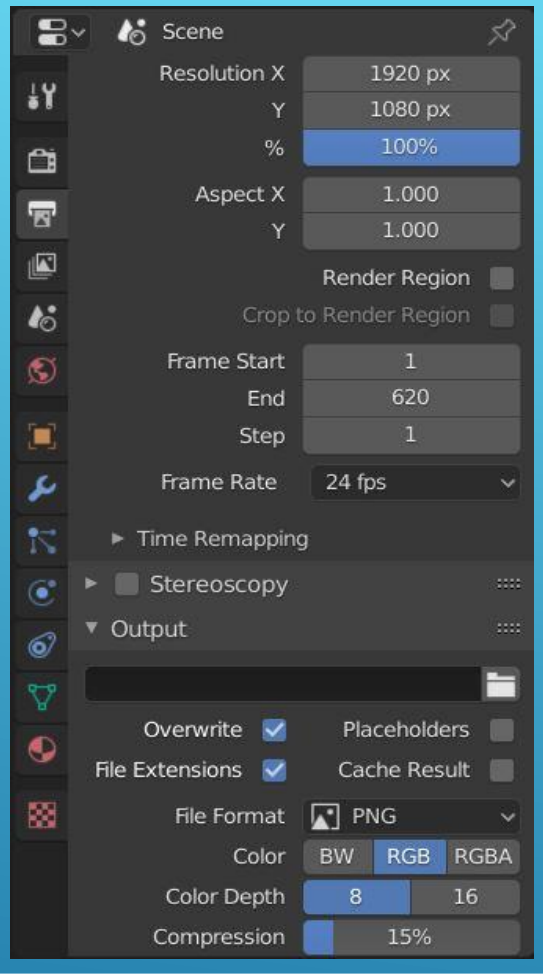
Dope Sheet

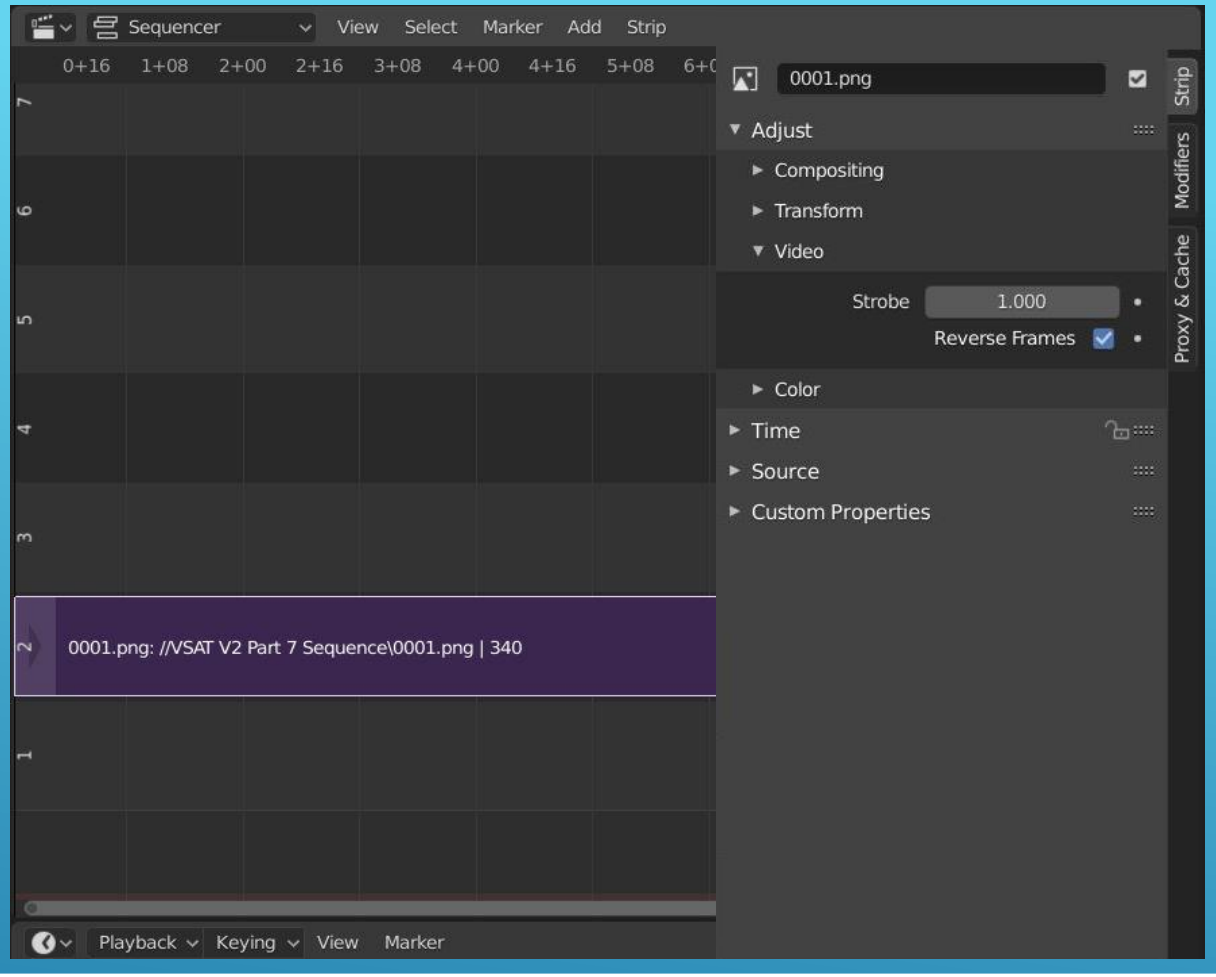


Graph Editor







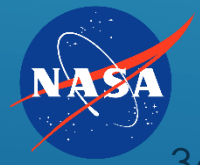


- Render properties
  - Engine
  - Samples
  - Performance
  - Bake

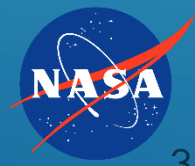
- Output properties
  - Resolution
  - Start / End Frame
  - Frame Rate
  - File Format

- Video Sequencer
  - Transform
  - Reverse Frames
  - Offset Timing
  - Filters

TERRAGEN



CHANGE OF PLAN

FUTURE WORK

- Positioning of solar array by rover animation
- Solar array on incline animation
- Mast pulley animation
- Variation with arrays that extend to the ground when fully deployed
- Physics-based animation in Blender
- Combining software