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Sandia National Laboratories

Technical Reachback Project

3D Spherical Display System

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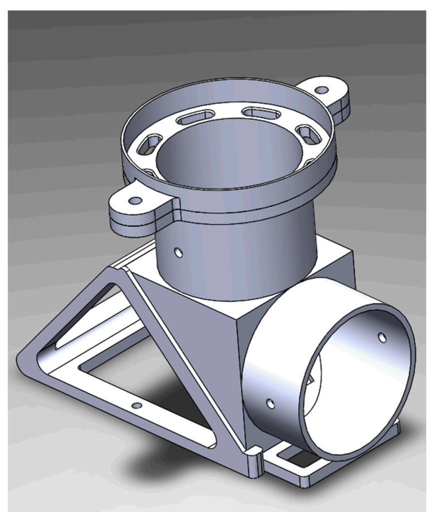
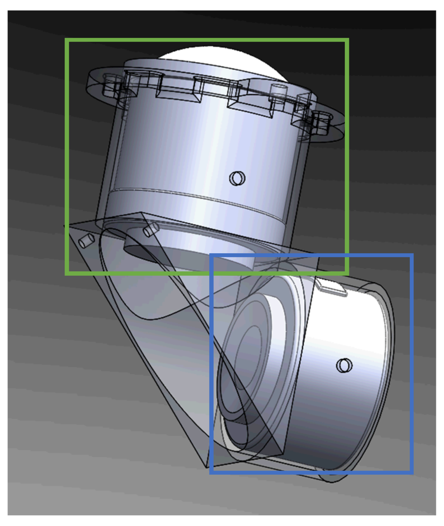
Abstract: As Sandia continues to analyze the data received from law enforcement and Customs and Border Protection, a more effective system is desired to display the geospatial information utilized by the Technical Reachback (TRB) team. This project focused on the development of a three dimensional projection system which can present data on a properly proportioned globe, allowing analysts to better understand and track data trends over time and location.

Designs: When designing the mounting system for the display, some of the most important factors to take into consideration are **weight, volume, size, and ease of manufacturing**. Each of these was addressed in various design iterations. Reducing the volume of material using cutouts and minimal wall thicknesses reduces manufacturing cost and using standard bolt sizes decreases the amount of auxiliary parts. The number of parts was also decreased from five to three by incorporating parts into others helping to minimize tolerance buildup and assembly time.

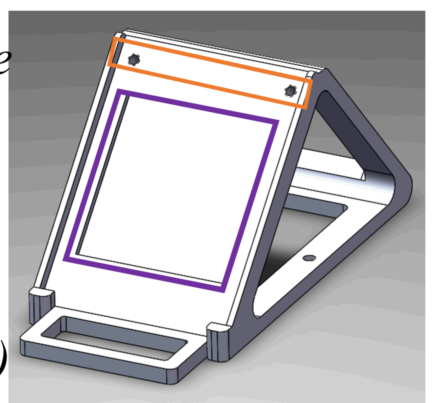
The image to the right shows the assembly of the mounting system which was 3D printed

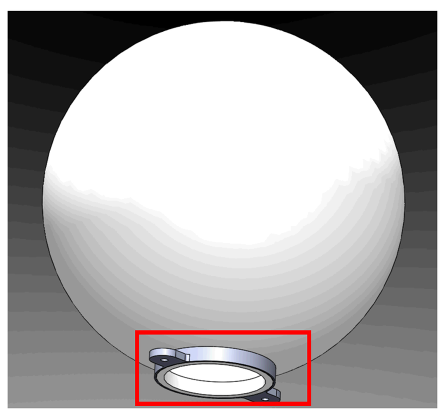




The left image shows the lens mount in transparent form, assembled with the lenses. The fisheye lens is boxed in green, and the rectilinear in blue.

To the right is the stand to which the lens mount is bolted (orange) and the mirror is attached (purple)





The bottom image shows the spherical fixture with the mount attached. It is pressed into the plastic mount (boxed in red), which is then bolted over the fisheye lens

Material choice is a key component in the design of this system, as any type of electronic device will produce some heat, and as all of the parts are connected to this one area, strength is also an important factor.

3D Printing Material					
Type	Machine	Strength (UT) psi	Coef. Thermal Exp. (in/(in-°F)	IZOD Impact (N/U) ft-lb/in	Other Features
ABS	Fortus 400mc, 250mc	4700	4.90E-05	N: 2.0	decently strong, okay with heat
ABSi	Fortus 400mc	5400	6.70E-06	1.8/3.6	translucent, really good in heat
PC	Fortus 400mc	8300, 6100	3.80E-05	1.4, 0.5/16.4, 3.5	good compressive strength, decent all around
Ultem 9085	Fortus 400mc	6800, 4800	3.67E-05	2.2,0.9/14.6, 3.2	strong, decent in heat
PPSF/PPSU	Fortus 400mc	8000	3.10E-05	1.1/3.1	highest heat resistance of any FDM material
Nylon 12	Fortus 400mc	6650, 5600	4.47E-05	2.8, 0.9/>37.4,5.1	high endurance strength
ABS-ESD	Fortus 400mc	5200	4.90E-05	0.5/1.1	good for electronics, no static charge
PC-ABS	Fortus 400mc	4250, 4000	4.10E-05	4/12	Combo of ABS and PC, strong and flexible
ASA	Fortus 400mc	4750, 4300	4.90E-06	1.2/6	Best aesthetics, UV stability
*does not include the material for polyjet printing **cost is $19.00 per cubic inch of material for all FDM materials					

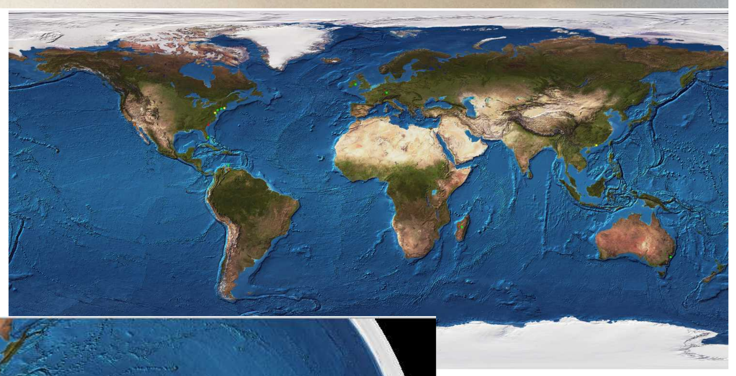
Projector type is also an important consideration. The table below highlights the properties of the types of projectors available for testing. These will be tested on the system to determine which projector yields the clearest, brightest image

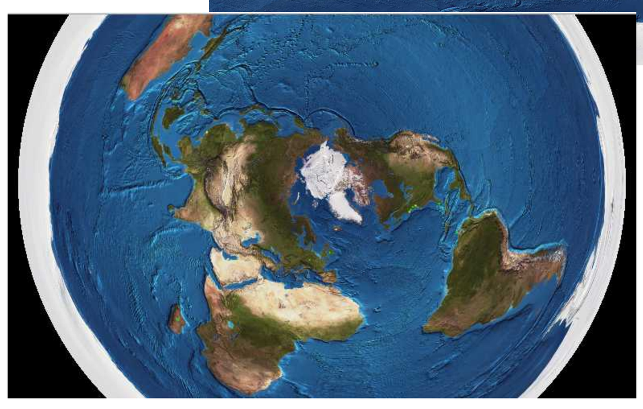
Projectors					
Projector	Type	Dimensions (in)	Resolution	Brightness (lumens)	Aspect ratio
Infocus 1100	DLP	7.2x8.3x2.5	1024x768	1550/2100	4:3
Infocus LP350	DLP	3.9x10.9x11.2	1024x768	1300	4:3
NEC LT260	DLP	10.2x4.7x11.8	1024x768	1650/2100	4:3
Epson EMP-710	LCD	10.5x8.4x2.8	1024x768	1000	4:3
Infocus 1102	DLP	2.5x8.3x7.2	1280x800	1650/2200	16:10
Christie DS30	DLP	9.6x10.9x3.5	1280x1024	3000	5:4

Lens choice is another significant decision in designing the display system. Tabulated below are all of the lenses which were considered for this application. Based on research of past designs and general photography products, it was determined that a **50mm focus rectilinear lens** and an **8mm focus fisheye lens** were the best choices for this application. Images of these are also shown below.

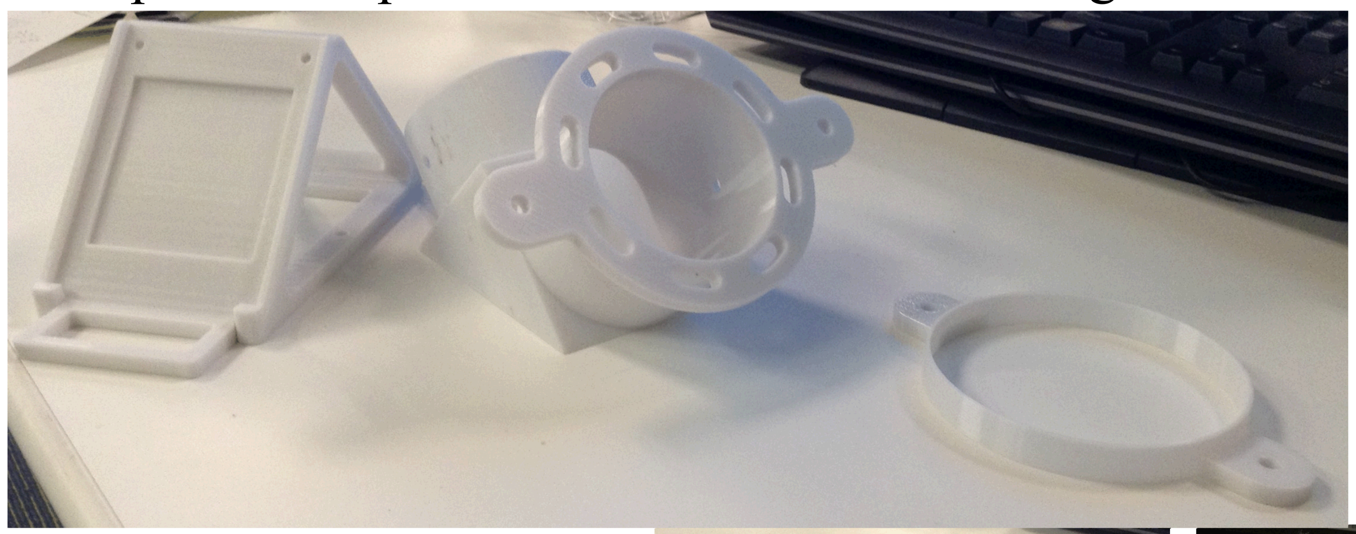
Lenses				
Make	Type	Focal Length (mm)	f/ ratio	Cost ($)
Heligon	Straight	75	1.1	60-160
Canon	Straight	50	1.8	125
Canon	Straight	50	1.8	53.99
Canon	Straight	50	1.8	85.67
Nikon	Straight	58	1.8	24.99
yongNuo	Straight	50	1.8	49.95
Canon	Straight	50	1.4	249.99
Canon	Straight	50	1.4	51.98
Nikon	Straight	50	1.4	68.99
Pentax	Straight	50	1.4	80
Rokinon	fisheye	8	3.5	258
Peleng	fisheye	8	3.5	239.95
EOS	fisheye	8	3.8	75
EOS	fisheye	8	3.8	69.56
Oshiro	fisheye	8	3.5	109.95
Nikon/canon	fisheye	8	3.5	146.88
Canon/Nikon	fisheye	8	3.5	163.5

Starting with an **equirectangular image** of the earth, data points are plotted with respect to location and number of occurrences. From there the image is translated into an **azimuthal equidistant projected image,** which then allows the image to be accurately projected onto a spherical surface. Shown to the right are examples of the equirectangular and azimuthal images with example points.





Shown below are the **final printed parts.** There are three separate pieces which each hold other purchased parts and will then be bolted together.



The images to the right show the display system **fully assembled** but without the projector, as well as how thee lenses will sit on the mounts. **Testing plans** include setting up multiple projectors of varying brightness and resolution to determine which outputs the **highest quality image**.

Future Implications: One of the reasons for building a custom display system rather than buying a commercial type is the associated cost. Some commercially - produced 3D spherical display systems start at $12,000 while the "home-made" alternative cost approximately $575 not including the projector. By finding an alternative method to achieve the desired image, new possibilities are available, such as producing a number of the same type of system in order to provide multiple data analysts their own individual systems without spending exorbitant amounts of money. Other possible improvements to be made could be incorporating an interactive display, where viewers can manipulate the display system through touch screen or motion tracking. This would allow for easier data analysis and trend comparison by providing an opportunity to incorporate features such as changing time or zooming in and out, into the display system itself rather than making changes from a computer. Other improvements would be to make the system more compact, further decrease cost, and improve image resolution.

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