

Zoom Lens Barrel Design

Preliminary Design Review

Dr. Jim Burge OPTI 523

David Sommitz

General

The goal of this project is to design a zoom lens mounting system. A pre-existing optical design will be used. However, the lenses will be custom and therefore must be specified. See the following website for the entire lens patent: (<http://www.kenrockwell.com/nikon/18-55-ii/patent-7277232.pdf>) The zoom lens barrel will need to be mounted to a specific mount type. The method for allowing zoom will need to be clearly specified and discussed.

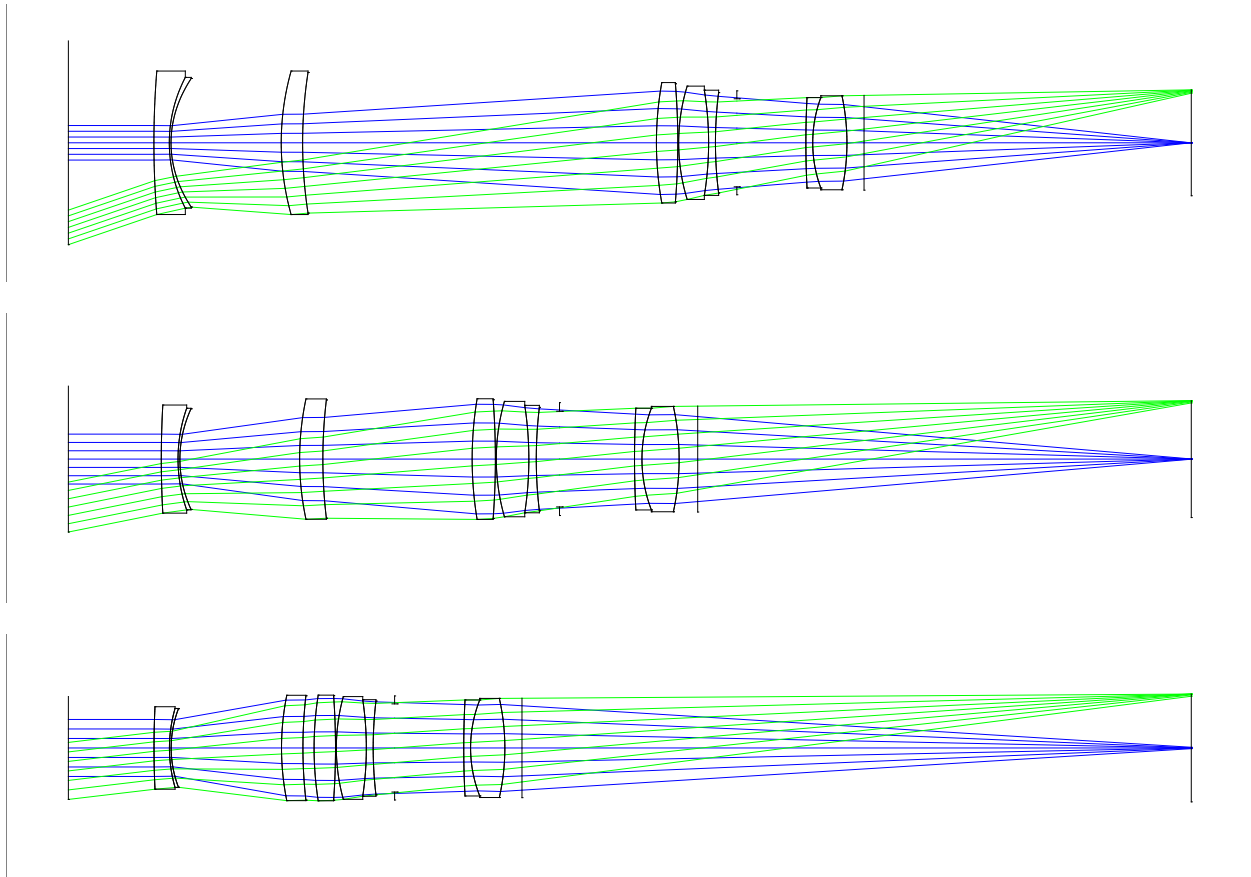
Key Requirements

- Operational Temperature: 20°+/- 15°
- Shock Loading: 20G
- Volume of production: 1
- Schedule: Flexible
- Lens Spacing: $\pm 100\mu\text{m}$
- Lens Group Spacing: $\pm 200\mu\text{m}$
- Lens Decenter: $\pm 50\mu\text{m}$
- Lens Tilt: $\pm 20\text{arcmin}$
- Intermediate Tolerances: spatial tolerances apply to intermediate zoom positions
- Mount Type: C

Lens Prescription

Surf	Type	Comment	Radius	Thickness	Glass	Semi-Diameter	Conic
OBJ	Standard		Infinity	Infinity		Infinity	0.000
1	Standard		Infinity	10.000		6.000	0.000
2	Standard		104.620	1.800	1.77, 49.6	4.808	0.000
3	Standard		16.500	0.200	1.55, 38.7	4.606	0.000
4	Standard		12.539	12.885		4.583	-0.479
5	Standard		30.943	2.500	1.81, 22.8	6.143	0.000
6	Standard	D5	53.571	1.303		6.088	0.000
7	Standard		39.679	2.500	1.64, 55.4	6.159	0.000
8	Standard		-84.183	0.100		6.102	0.000
9	Standard		22.469	3.500	1.52, 64.1	5.990	0.000
10	Standard		-37.953	0.800	1.80, 46.6	5.630	0.000
11	Standard		46.568	2.500		5.464	0.000
STO	Standard		Infinity	8.072		5.140	0.000
13	Standard		104.913	0.800	1.83, 37.2	5.598	0.000
14	Standard		15.211	4.000	1.52, 64.1	5.592	0.000
15	Standard		-26.189	2.000		5.777	0.000
16	Standard	D15	Infinity	78.142		5.794	0.000
IMA	Standard		Infinity	-		6.284	0.000

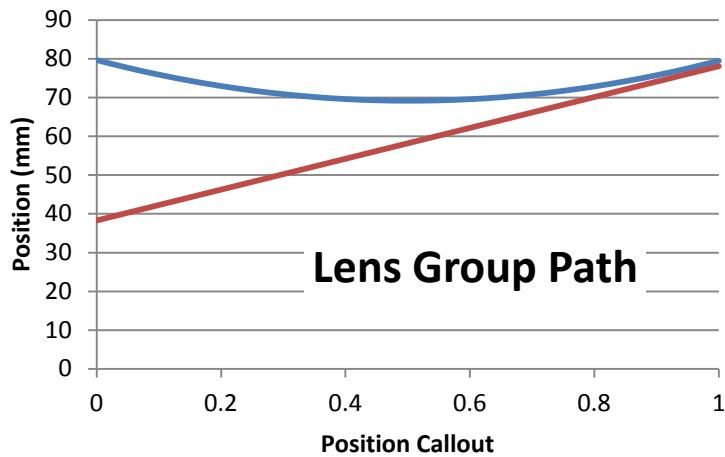
Zoom Configurations



Lens Group Path

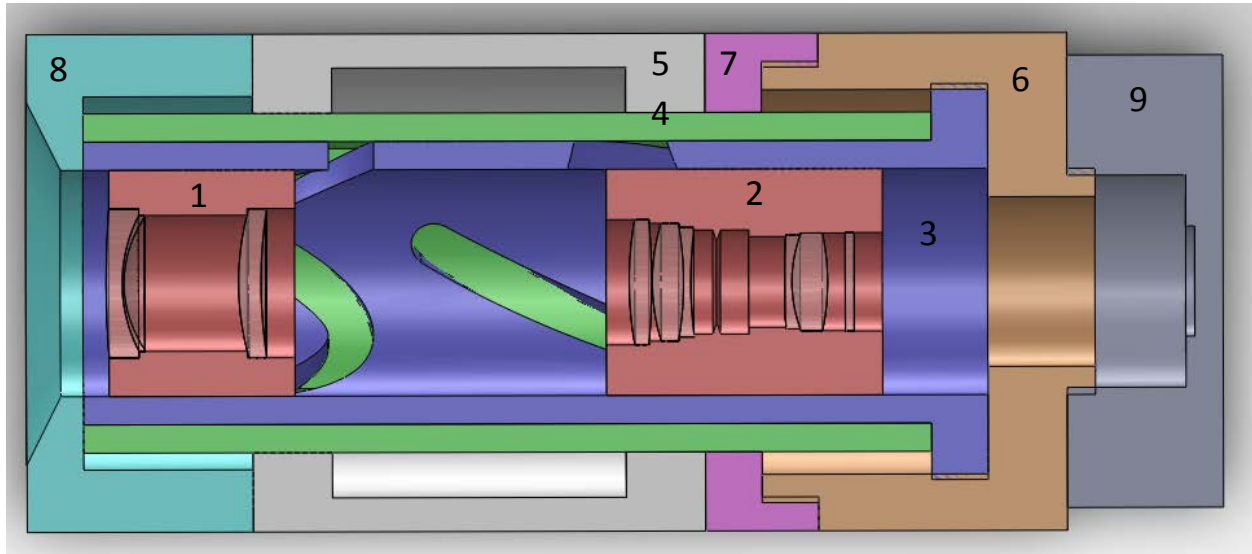
Group 1 (Spacing 1, D5): Quadratic from $x=0$ to $x=1$: $\text{Position}(x)=41.412x^2-41.588x+79.621$

Group 2 (Spacing 2; D15): Linear from $x=0$ to $x=1$: $\text{Position}(x)=39.8x+38.3$



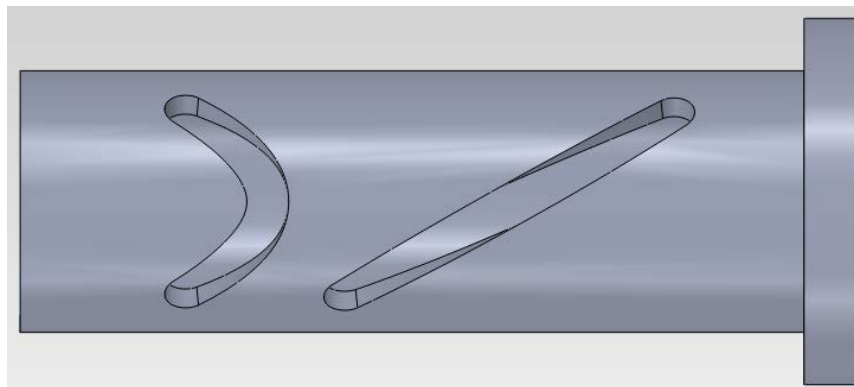
Design Concept

Assembly Cross Section

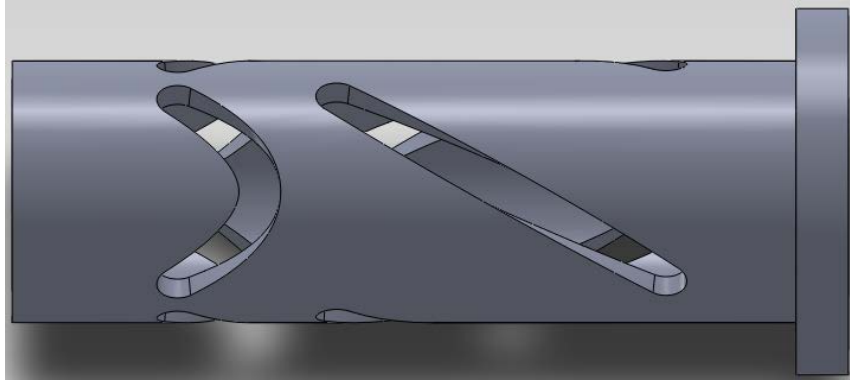


1. Lens Group 1 Subcell
2. Lens Group 2 Subcell
3. Cam Shaft (lens movement path)
4. Cam Guide (straight lines)
5. Cam Guide Attachment (for accessibility)
6. Focus Compensator
7. Compensator Fastener
8. Cam Shaft Cap (holds parts in place)
9. C-Mount Interface

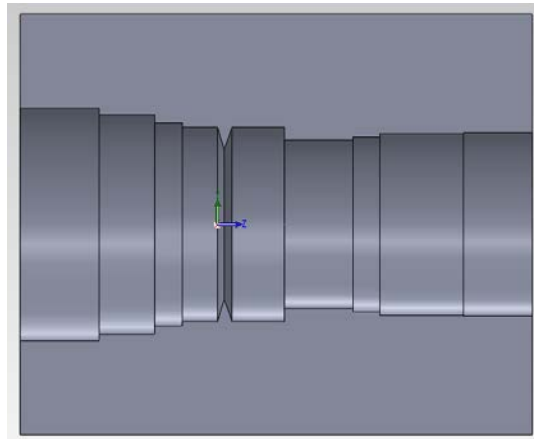
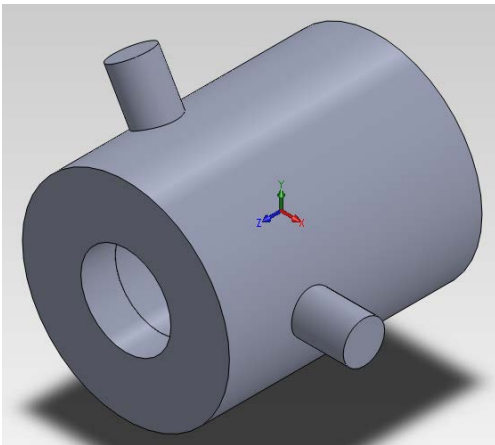
The general concept of this design will follow a basic cam with the path of the lens groups cut into the shaft:



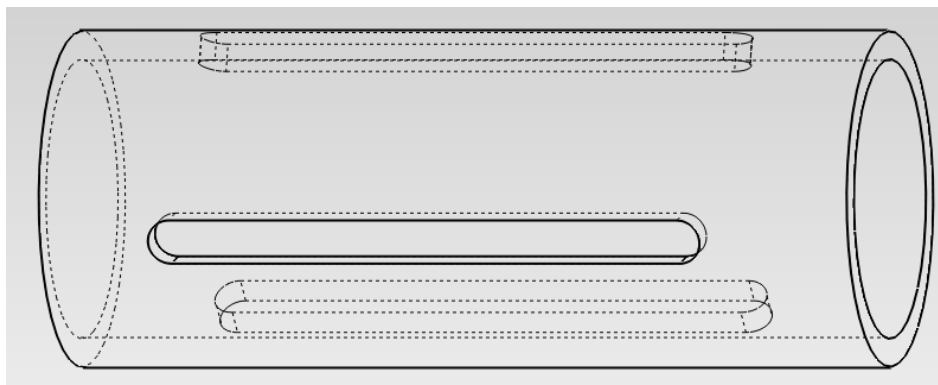
Two additional cuts will be placed equidistant around the shaft:



The two groups of lenses will be mounted inside two individual barrels, which will move with the cam for zoom paths. Three rods are attached to the barrel, which will follow the cam cuts to extend the zoom.



The inner tube will contain three equi-spaced cuts that are in the shape of the lens paths. The outer tube, which will be the part that is rotated to adjust zoom, will have three linear cuts.



Error Budget

Temperature Expansion-Lens Mounting

The lenses will not expand at the same rate as the barrels inside which they are mounted. This will be accommodated with using RTV epoxy, which has an appropriately large CTE as well as a low elastic modulus (see previous design).

Temperature Expansion-Lens Spacing

The spacing of the lenses will increase with temperature expansion. This expansion is acceptable because it stays within the requirements:

$$\Delta L = L * \Delta T * \alpha = 1.5in * 15^{\circ}C * \frac{23ppm}{^{\circ}C} = 0.5 \text{ millinches} = 13\mu m$$

Temperature Expansion-Cam Alignment

As long as the components that are involved in zoom movement are made of the same material, temperature should not affect the alignment of the components.

Shock Loading- Lens Mounting

These lenses are somewhat larger than the previous lens designs in this class. However, the bond strength of the epoxy used should be enough to prevent 20G shock loading from damaging the lens mounting. As long as the contact area is greater than the required surface area to prevent movement at 20G, the lenses will meet the requirement.

Mass of largest lens: 1.22 grams

Maximum force from shock loading: 0.239N

Tensile Strength of Epoxy: 310 lb/in²=2MPa

Minimum Contact Bond Area: 0.12mm²

Shock Loading-Cam Alignment

20G shock should not damage the cam alignment because everything is constrained, but further analysis is required to confirm this.

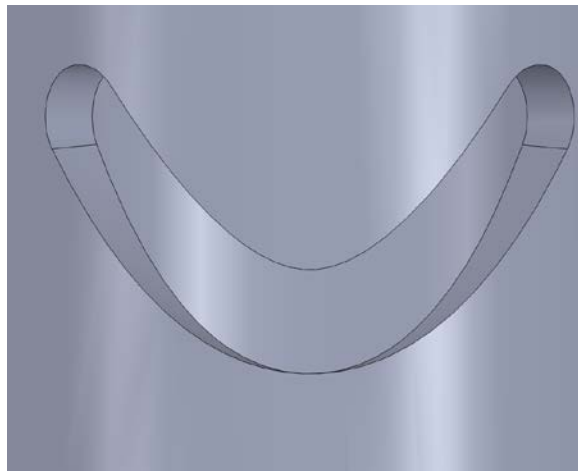
Design Issues

Thread Lubricant

In order to prevent galling, seizing, and binding, a lubricant will be used between moving parts in the assembly. This will need to be inserted into the assembly without causing leakage. When the zoom assembly is extended, lubricated parts will be exposed. This could be a problem.

Corner on Cam

When the lens is being moved through zoom, there is a point where it will bottom out and start moving in the other direction. While this should not be an issue, it is hard to tell whether this change in direction will cause problems.



Focus Adjustment

When the focus adjustment is applied, the front part of the barrel should be twisted relative to the back of the camera. When zoom is adjusted, however, the middle part of the barrel is twisted relative to the front of the barrel. This could be a confusing feature for consumers.

Material List

Machined Parts: Aluminum Alloy 6061 (Anodized)

Lubricant: LAMONS Thread Lubricant/Anti-Sieze (GP 450)

<http://www.lamons.com/products/thread-lubricant.html>

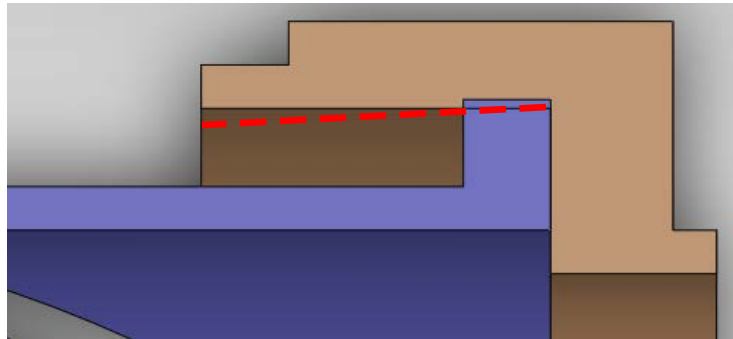
Epoxy (for mounting lenses): Sil-Bond RTV 4500 Aluminum Industrial

<http://www.industrialproducts.com/Sil-Bond-RTV-4500-Aluminum-Silicone-Sealant-p/rtv4500aluminum.htm>

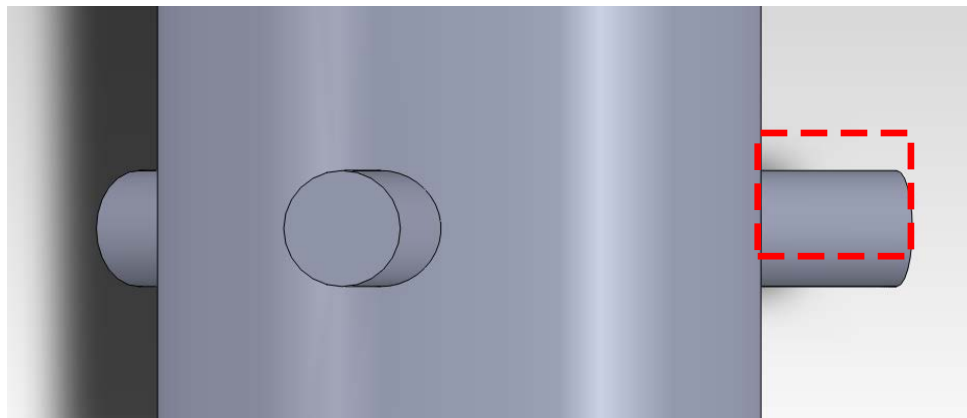
Potential Problems

The following issues should be preventable with the proper tolerancing.

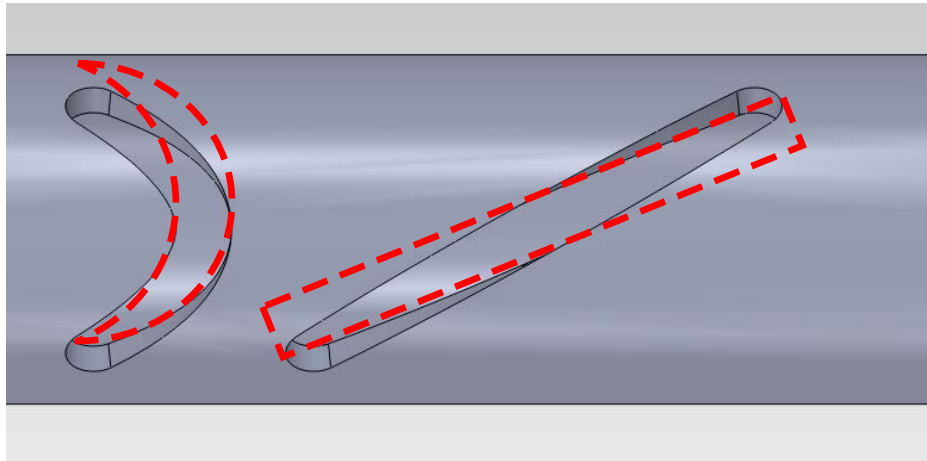
Focus Compensation Binding –When the focus is adjusted, if the threads are not precisely machined and the materials are not properly centered, the camera will bind. This will be prevented with a position tolerance (concentricity) on the cam guide as well as the compensator part. This tolerance will need to be done before the parts are tapped.



Error in Guidepost Location – The general location of the posts is not terribly important, since the focus can be adjusted. However, the position of the posts relative to each other is very important. If the posts are not properly centered, the lens subcells will not be able to be placed in the cam shaft.



Cam Cut Error – When the guides for the cam shaft are cut, they must be within an acceptable position and orientation of each other. Similarly to the guidepost location, when the zoom is adjusted, any error in the location and orientation will prevent the system from adjusting smoothly.



Size of Guideposts – There are two conflicting limitations on the diameter of the guideposts. If they are too big, they will either not fit in the cam cuts or they will not be able to move. Conversely, if they are too small, there will be a dead zone in the movement of the lens groups.

