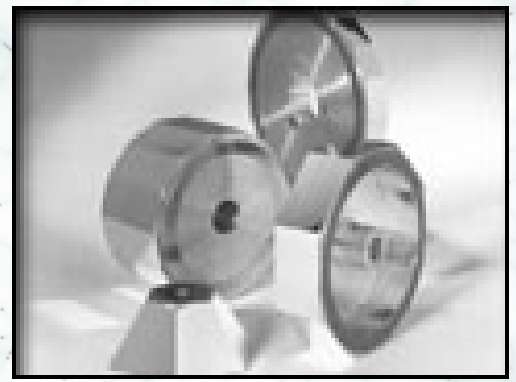
Polarization Lab

Polygonal Mirror Assemblies



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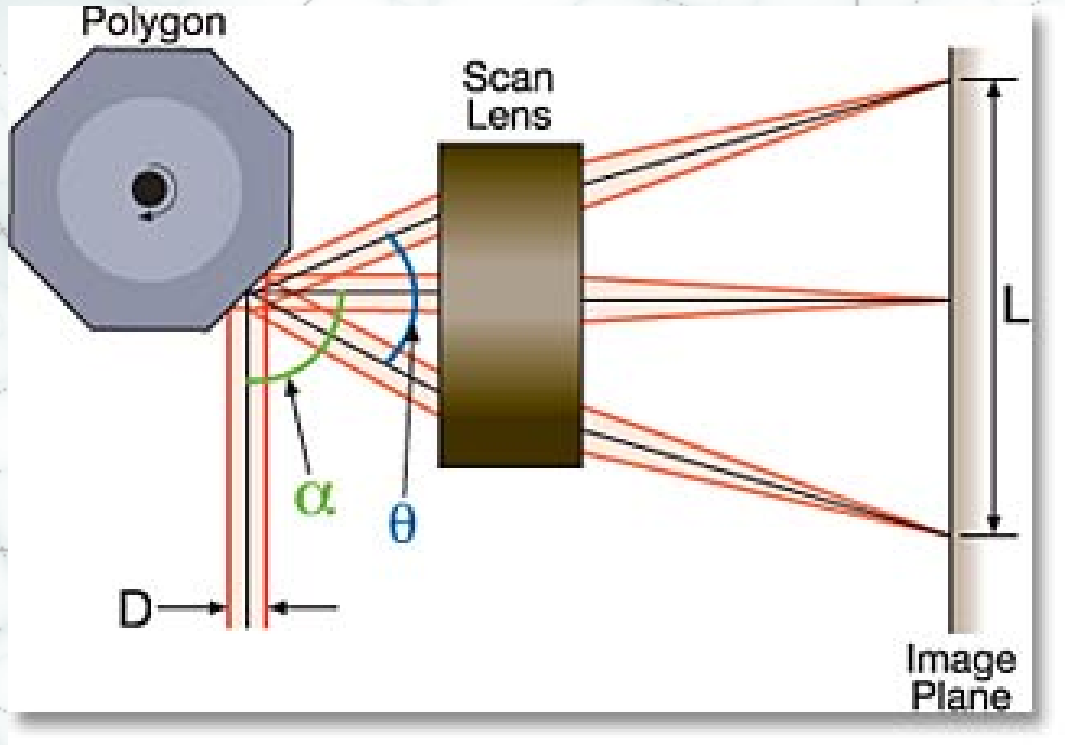
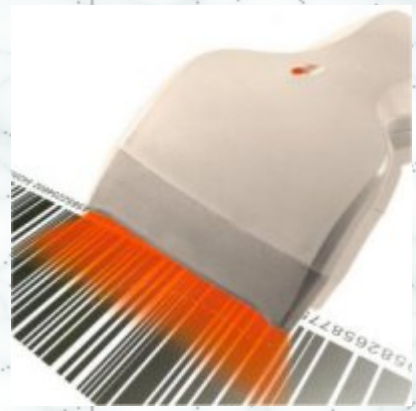
The basic idea



Applications

- Laser printers
- Laser marking
- Bar code scanners
- Imaging devices, esp. biomedical
- Sorting and inspection



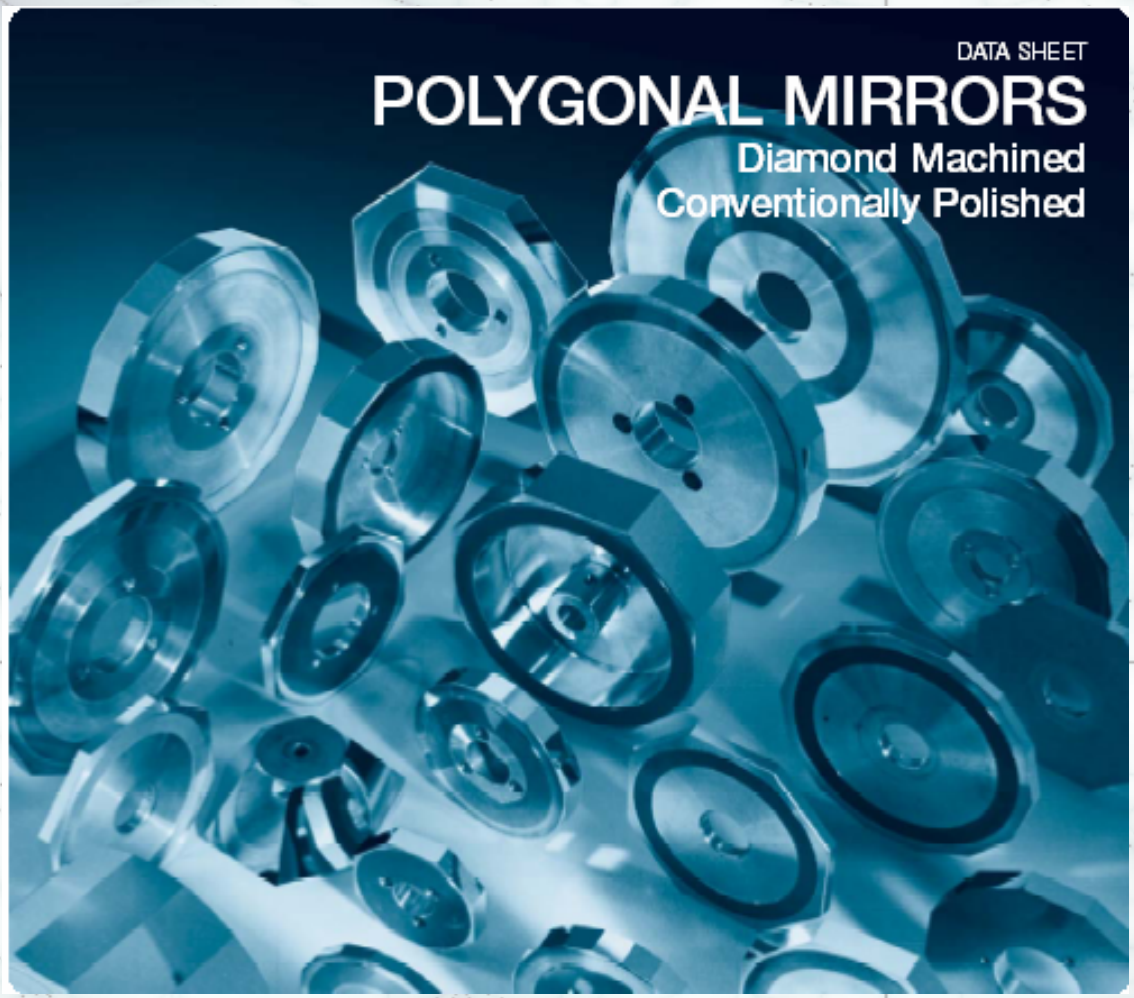
Advantages

- High speed
- High resolution
- Uniform velocity
- Flexibility
- Can be small and inexpensive

So many variations…

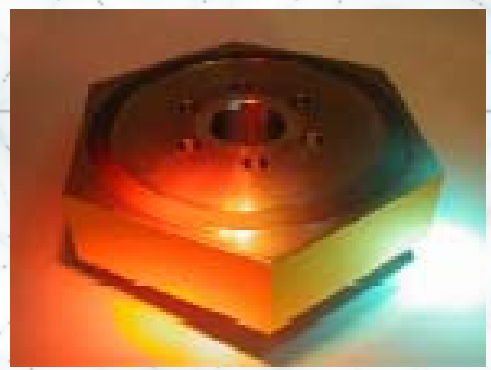
- Number of facets
- Facet dimensions
- Facet angles
- Facet curvatures
- Facet features, such as diffraction gratings

So many variations…



Preliminary Design Considerations

- The outgoing beam
- The incoming light
- Mechanical design



System Design – outgoing beam

- Scan pattern
- Scan length
- Scan speed
- Wavelength
- Spot size in scan plane
- Distance to scan plane

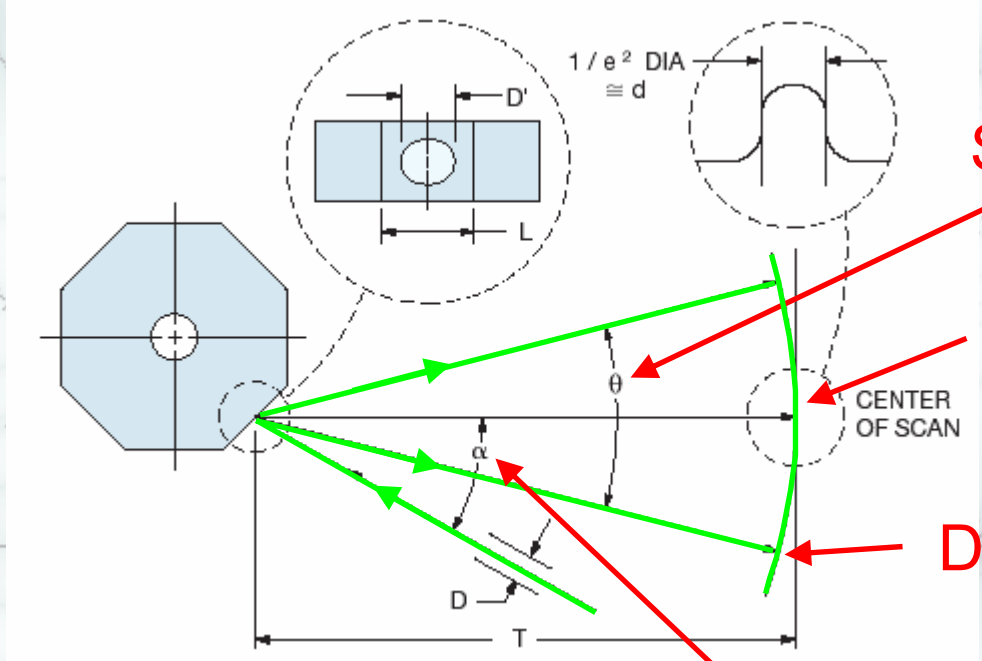
System Design – incoming light

- Collection aperture
- Distance from scan plane
- Wavelength

System design - mechanical

- Available space
- Beam feed angle
- Scan extent inside system
- Motor selection
- Mating to motor

Where to start?



Scan angle θ

Beam diameter d

Duty cycle C

Beam feed angle α

Basic Calculations

Number of facets:

$$n = \frac{720C}{\theta}$$

Beam diameter:

$$D = \frac{1.27\lambda T}{d}$$

T: distance to scan plane, or focal length of scan lens

Beam footprint on facet:

$$D' = \frac{1.5D}{\cos(\alpha/2)}$$

Basic Calculations

Facet length

$$L = \frac{D' + 1}{1 - C}$$

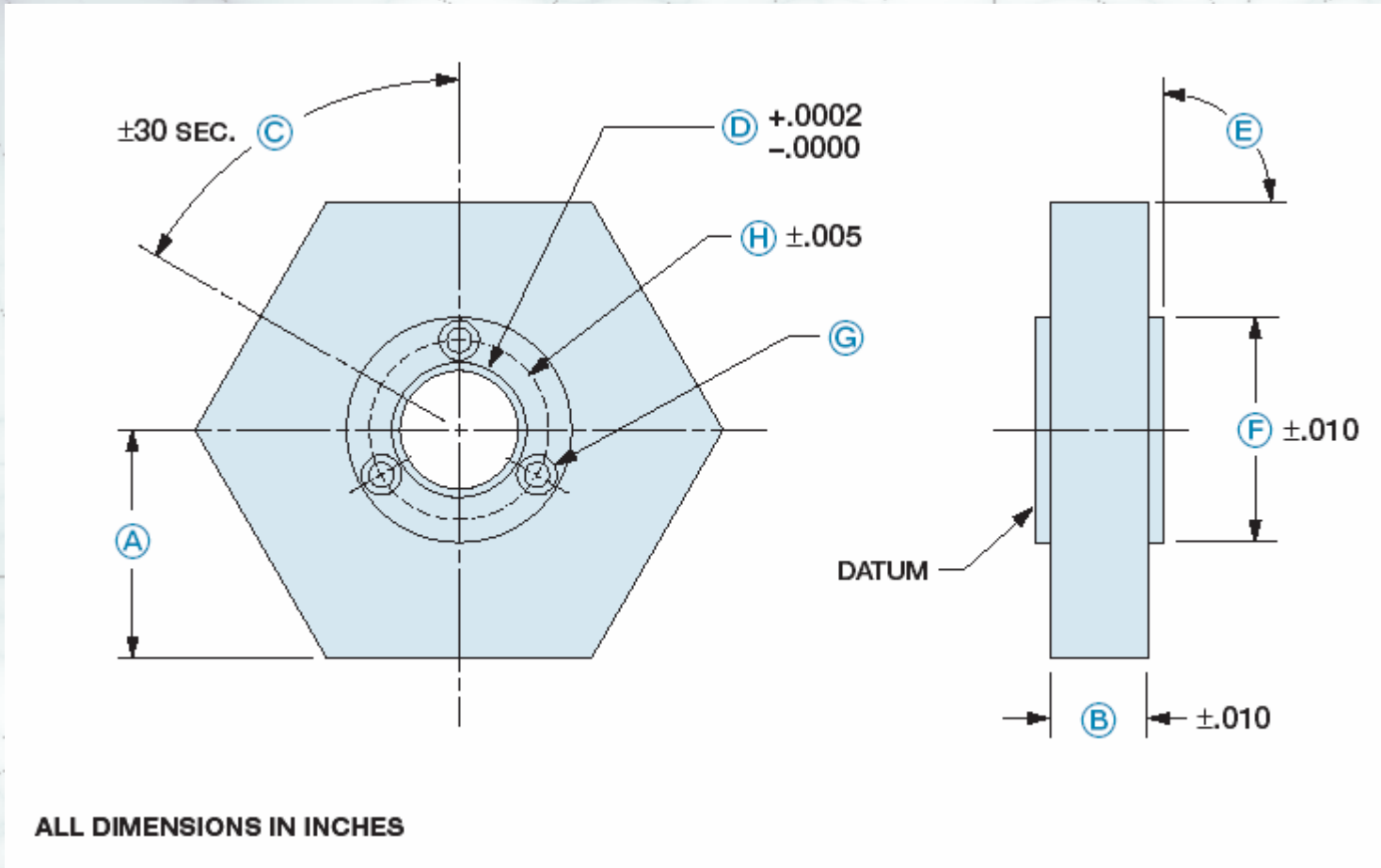
Polygon diameter

$$Diam = \frac{L}{\tan(180 / n)}$$

Making the polygon smaller

- Reduce facet length
  - Increase vignetting at edges
- Reduce duty cycle
  - Fewer facets, faster scanning
- Reduce feed angle

Typical mechanical drawing



Surface Roughness

Scatter is a strong function of wavelength and manufacturing technique

Typical surface roughness is 20-80Å

WAVELENGTH	DIAMOND TURNED SCATTER	POLISHED SCATTER
488NM	3.7 %	0.64 %
633NM	2.2 %	0.38 %
820NM	1.3 %	0.23 %
1.06 MICRONS	0.8 %	0.13 %
10.6 MICRONS	0.08 %	0.001 %

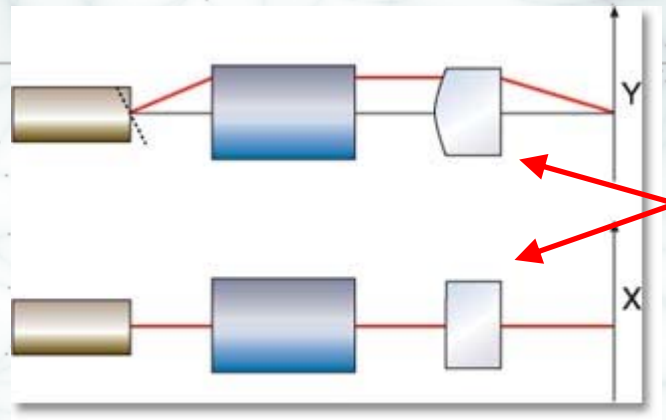
Facet Flatness and Accuracy

- Lack of flatness leads to beam aberrations, pointing errors, and jitter

Typical flatness spec is λ/4 to λ/8

- Facet tilt errors lead to tracking errors

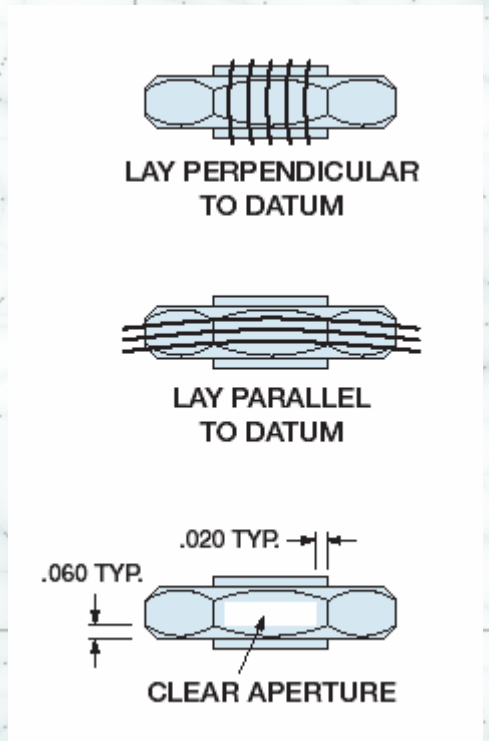
Typical tracking spec is 10-45 arcsec



Cylindrical lens

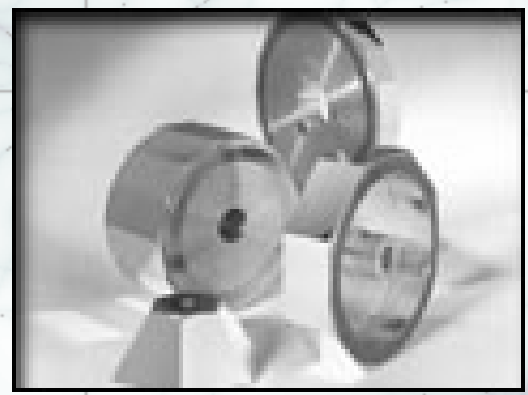
Other specifications

- Facet clear aperture
  - Active area where specs apply
- Lay direction
  - Surface pattern generated by diamond tool



Materials

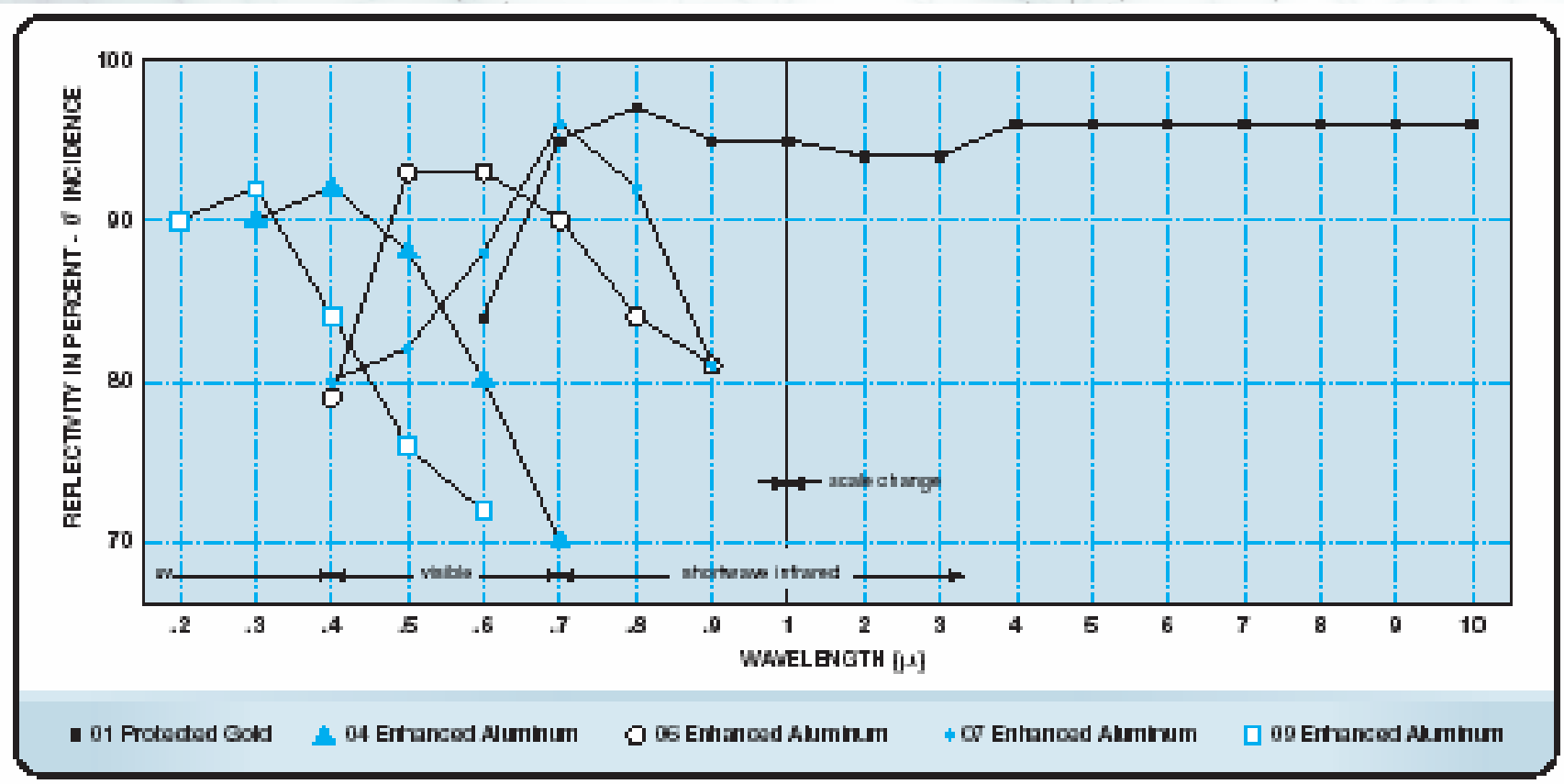
- Aluminum – durable, easy to work, light
  - Diamond machined surfaces (high scatter)
  - Plated with nickel and polished
  - Mirrors glued onto surfaces
- Molded Plastic – cheap in high volume
- Glass
- Beryllium – rigid at high rpm



Coatings

Enhanced Aluminum
for UV and visible

Gold for IR



Other considerations

- Bonding mirrors to polygon substrate
  - Adhesive type (small amt of rtv)
  - Mirror not too thin or will distort
- Facet distortion at high rpm
- Laser damage threshold

Motor considerations

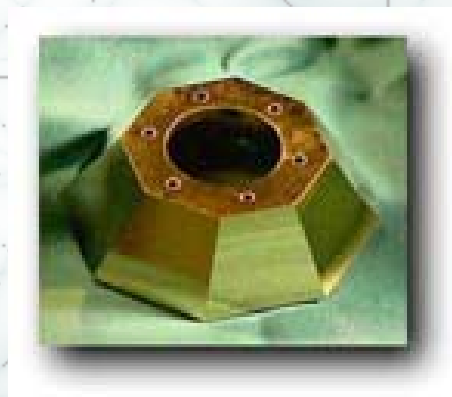
- Speed
  - 500-4000rpm is typical range
  - Can achieve up to 60,000 rpm
- Weight of polygon
- Stability, jitter requirement
- Low speed, low weight systems may need encoders to stabilize velocity

Motors

- Ball bearing motors
  - For heavier polygons, 1000-45,000rpm
  - Inexpensive
  - Susceptible to damage and instability
- Air bearing scanners
  - For smaller polygons, 6000-55,000rpm
  - Very expensive

Coupling to the motor

- Captured design
  - Polygon on rotating spindle
  - Spindle held on both ends
- Cantilevered design
  - Polygon is outside bearing system



Mechanical design can be complicated

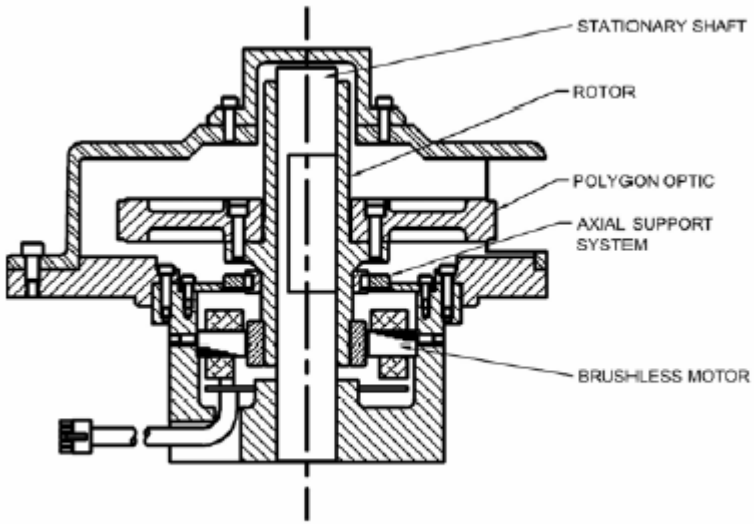


Figure 1: Motor polygon assembly (MPA) cut-away view.

Conclusions

- Polygon scanners offer flexibility
  - Size
  - Speed
  - Facets
- There are a lot of design considerations
  - Optical specifications
  - Materials and coatings
  - Motor type and coupling