Design-for-Excellence (DFX)

Nathan Wallace

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Optikos

Overview

- What is DFX and What is its value with developing optical systems?
- Applying DFX to an optical system manufactured in moderate volumes
  - Design for Manufacturing (DFM)
- Applying DFX to a prototype optical system
  - Design for Assembly/Modularity (DFA)
- Applying DFX to a serviceable optical system
  - Design for Service (DFS)
- Closing remarks

What is DFX?

- DFX, Design for Excellence, this just seems like a buzzword
- The ‘X’ in DFX can take on many important features when developing an optical system
- Design for:
  - Manufacturing, Assembly, Service, Modularity, Cost, and really any parameter that is important
- It may not be possible to achieve all design parameters, but a select few can be optimized
- DFX the most value when applied very early in a development effort

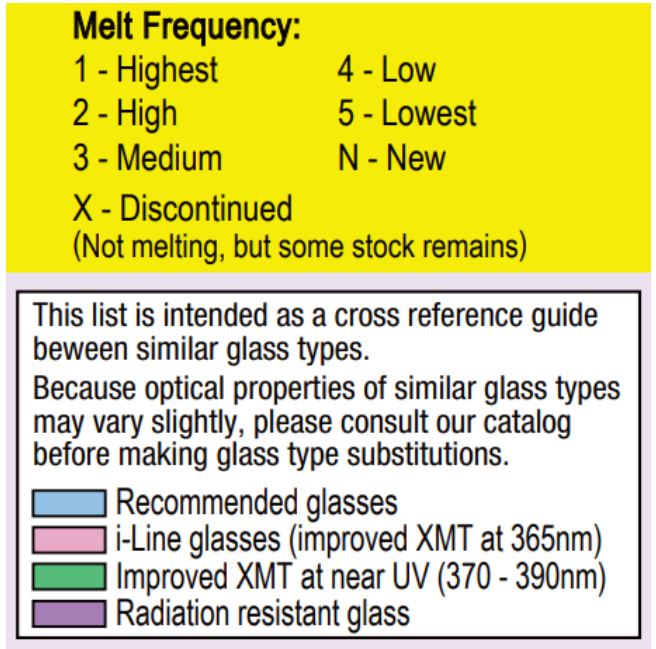
Where To Start With DFX

- Start with high level product needs
  - Is there cost sensitivity?
  - Is reliability or service important?
  - Is performance the key product driver?
- Generate a matrix and list the DFX principles that apply
- Finally, produce a list of design implementation areas that can be prioritized by the development team

Customer Need	DFX Principle	Design Implementation Examples
High optical performance	Design for Performance (DFP)	Minimize aberrations, ensure high resolution or throughput, and add compensators to recover performance
Low manufacturing cost	Design for Manufacturability (DFM), Cost (DFC)	Use standard optics, design components for use in multiple areas, relax tolerances, and reduce part count
High reliability	Design for Reliability (DFR)	Shock/vibration-proof, thermally stable design
Prototyping	Design for Assembly (DFA), Modularity	Simplified assembly, modular design
Ease of service/upgrade	Design for Serviceability (DFS)	Access to components that require frequent service, highly modular components

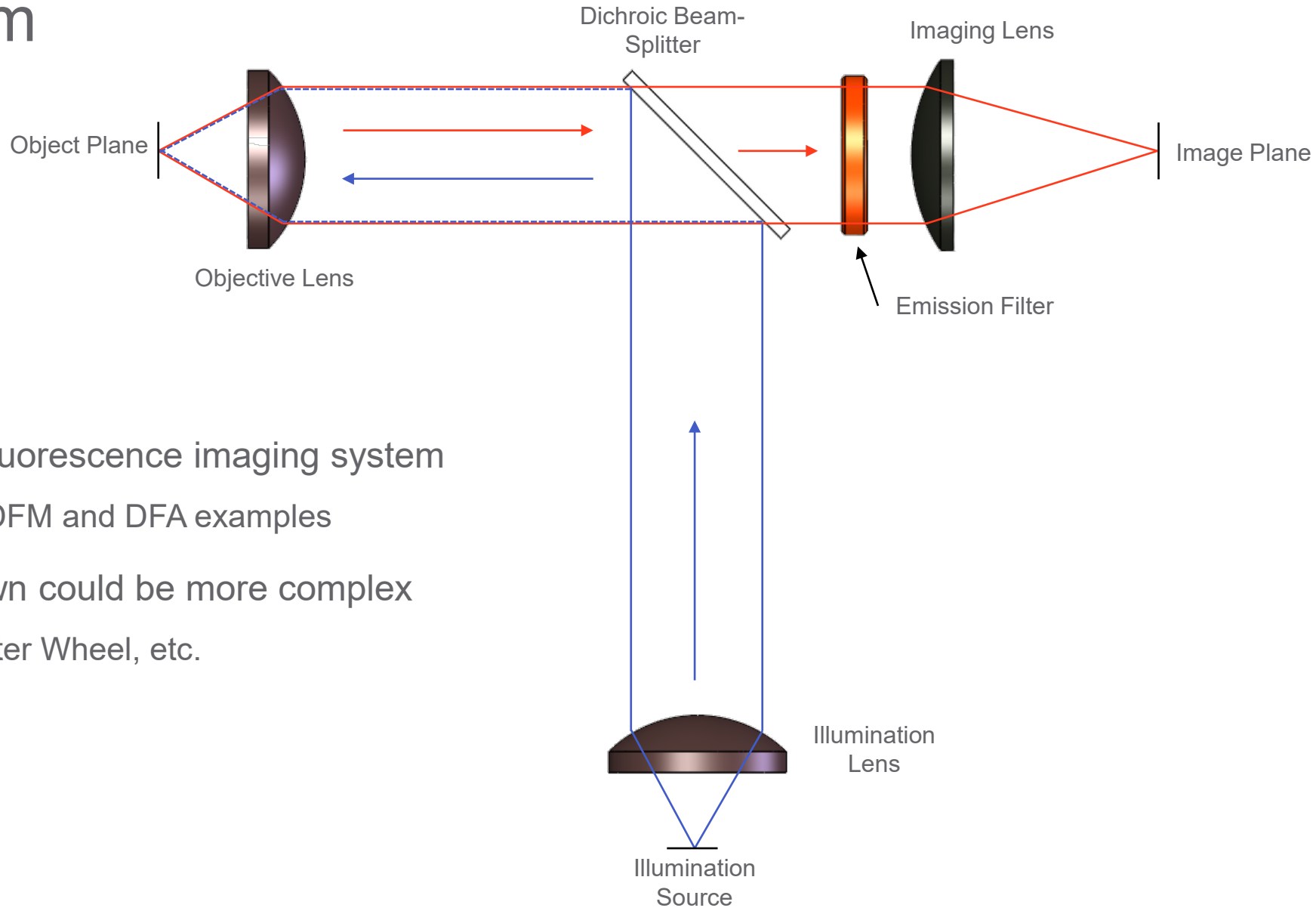
Design for Manufacturing (DFM) – Optical Systems

- Key attributes for DFM:
  - Simplification
    - Choose an optical architecture that has low complexity where possible
    - Use standard parts or reuse components throughout
  - Material Selection
    - Use common / high melt frequency glasses
    - Avoid materials that are challenging to manufacture
  - Optimization for Manufacturing Process
    - Use conventional techniques where possible – standard polishing, standard coating, etc.
  - Minimize Part Count
    - Limit parts to essential functionality only – combine parts where appropriate



Ohara Corp

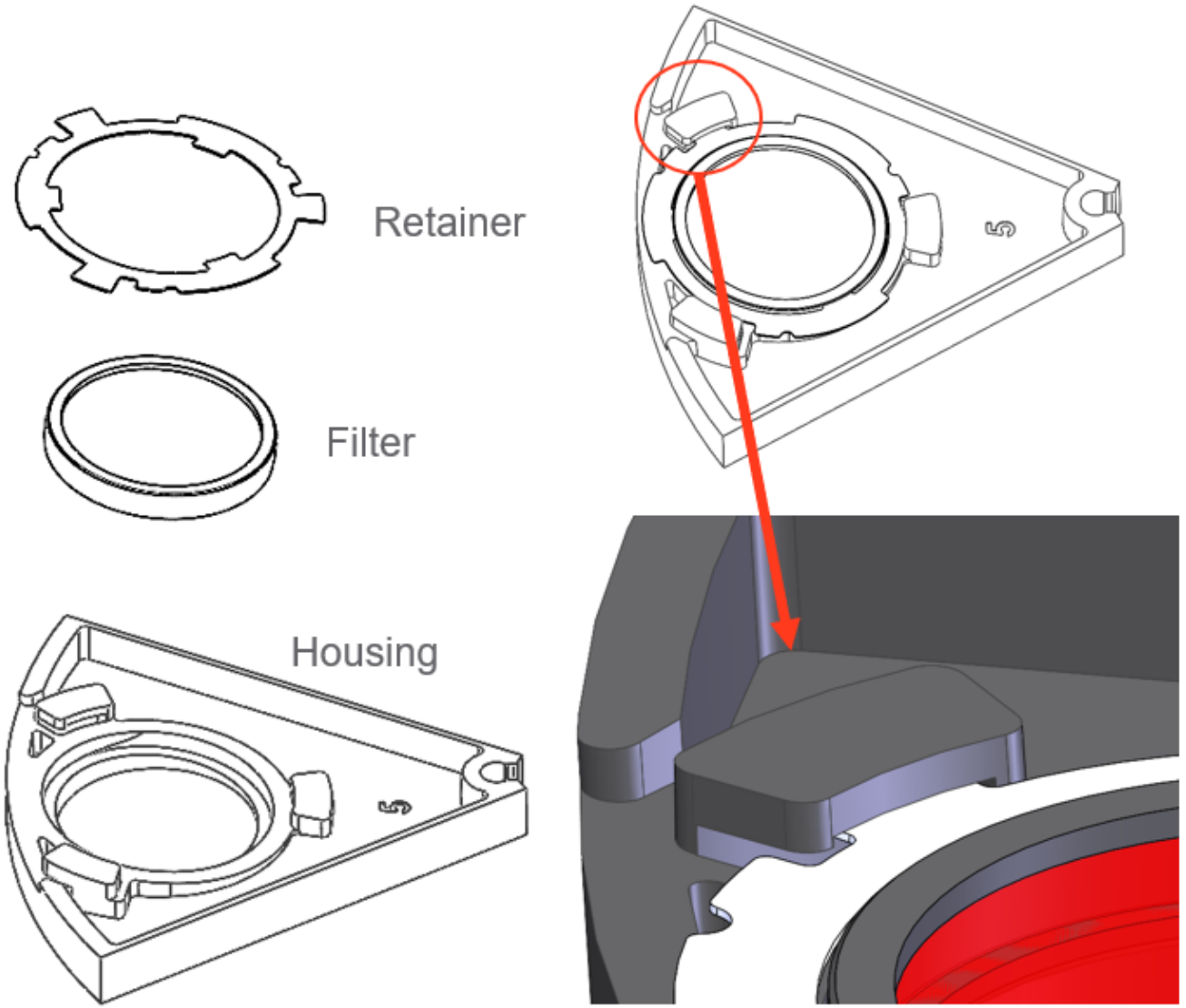
The Optical System



- High-level layout of a typical fluorescence imaging system
  - We'll use this for some of the DFM and DFA examples
- Many of the components shown could be more complex
  - Objective Lens, Tube Lens, Filter Wheel, etc.

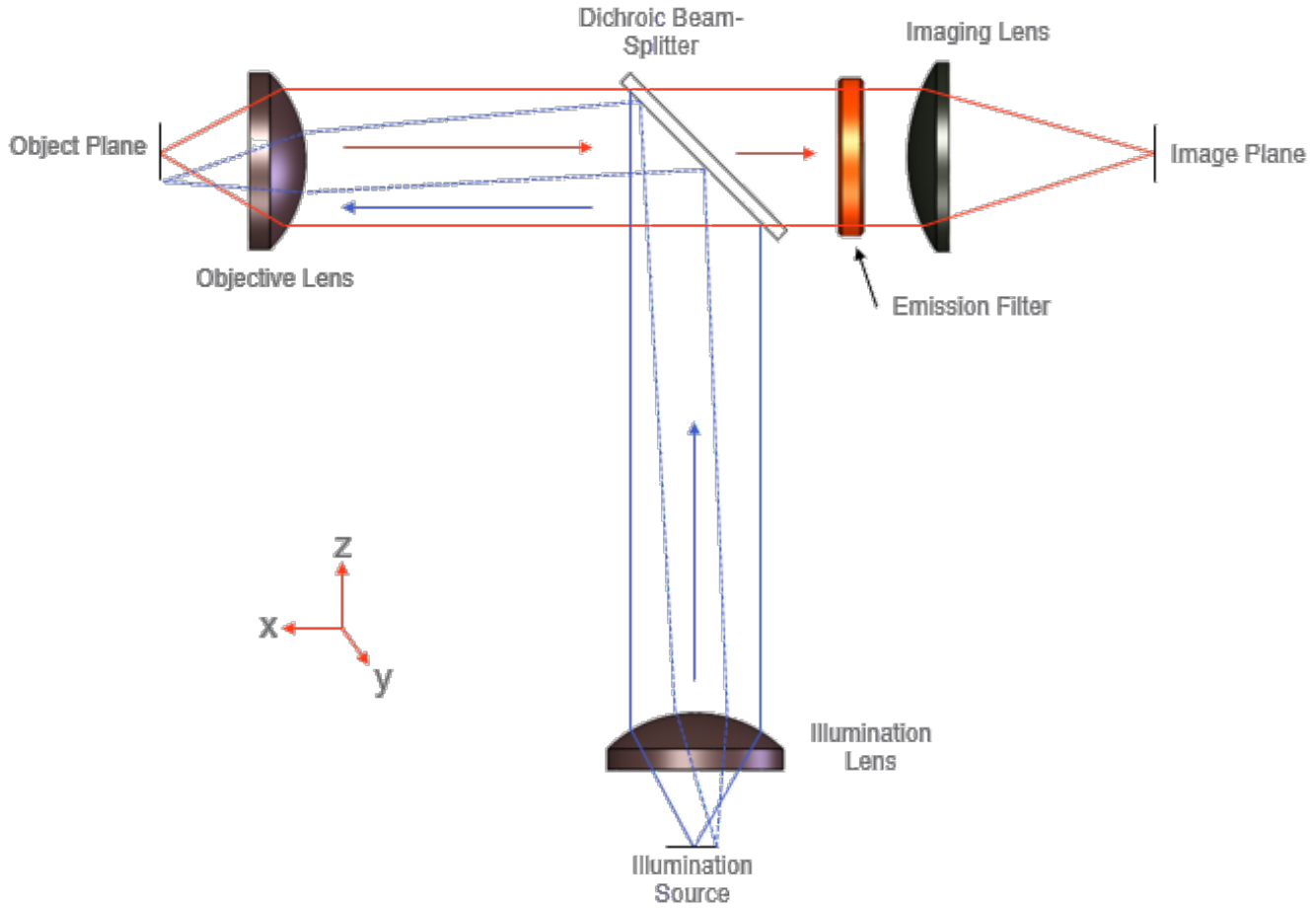
Design For Manufacturing (DFM) Example

- Injection molded filter housing
- COTS filter (ring mounted)
- Photoetched stainless steel retainer
- Eliminates traditional fasteners
- Ease of installation with custom spanner tool



Design For Manufacturing (DFM) Example

- System level alignment strategies can have a large impact on manufacturability
- Rather than align every component, calculate errors from hard mounting and push the required alignments to one component if possible
- The illumination source can be translated to accommodate angular errors in the beam-splitter as well as the lens(s)

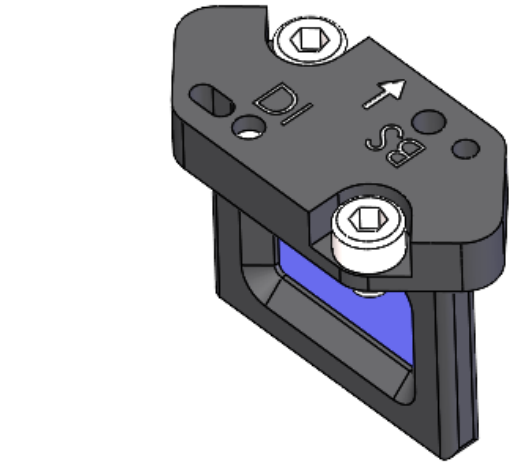


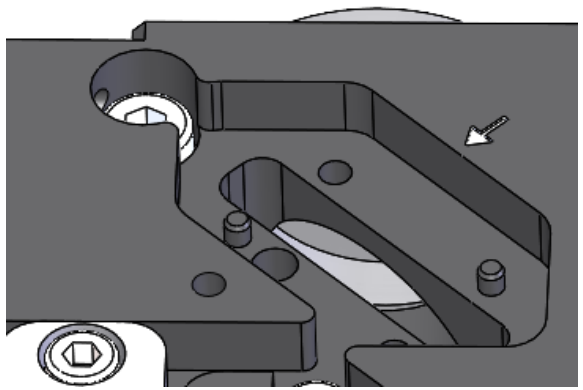
Design for Assembly (DFA) – Optical Prototypes

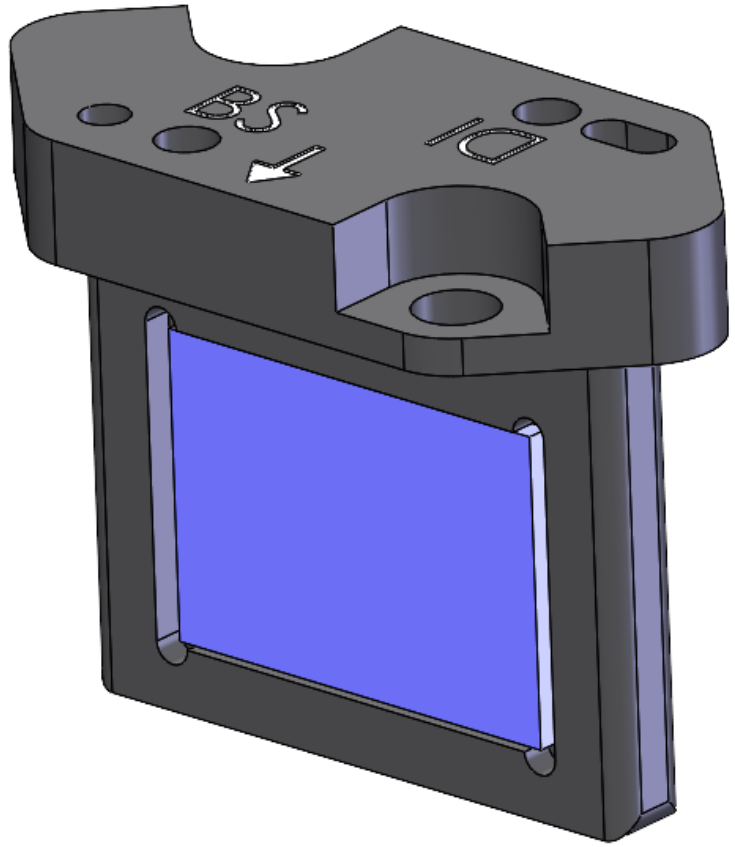
- Key attributes for DFA
  - Standardized Parts
    - Maintain consistent design forms for parts with similar assembly interfaces
  - Modular Designs
    - Create modules that can be verified prior to integration into the product
  - Easy to Handle Components
    - Design components that can be easily handled or manipulated with a tool

Design For Prototyping Example (Leveraging Modularity)

- Designing for a prototype presents some unique challenges
- A small amount of additional design time up front can enhance system testing and the evaluation of alternate components
- Designing standard modules allows for easy replacement or testing
- Beam-splitter mount shown with pin/slot location features, labeling and lockout pins

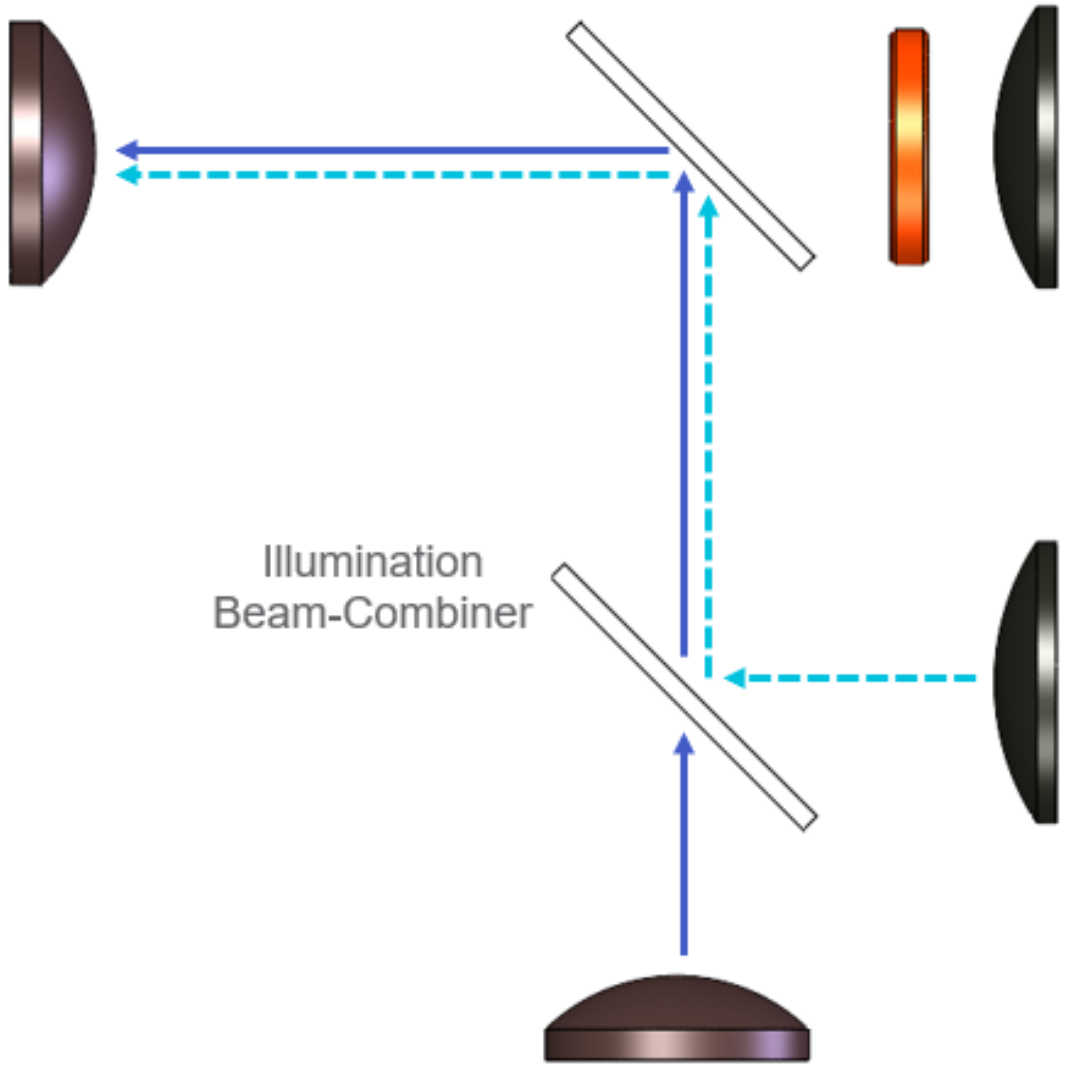






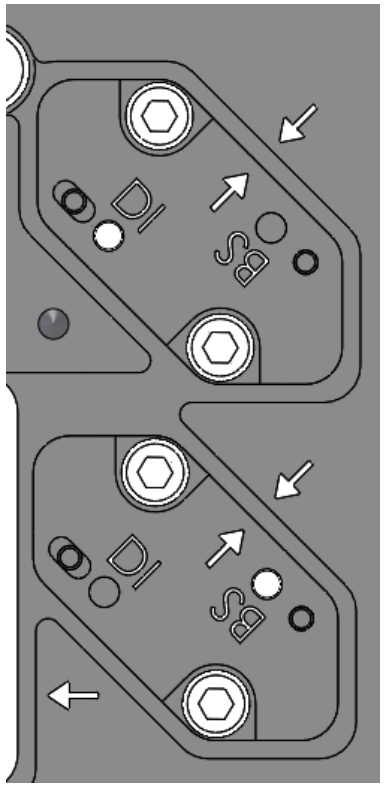
Design For Prototyping Example (Leveraging Modularity)

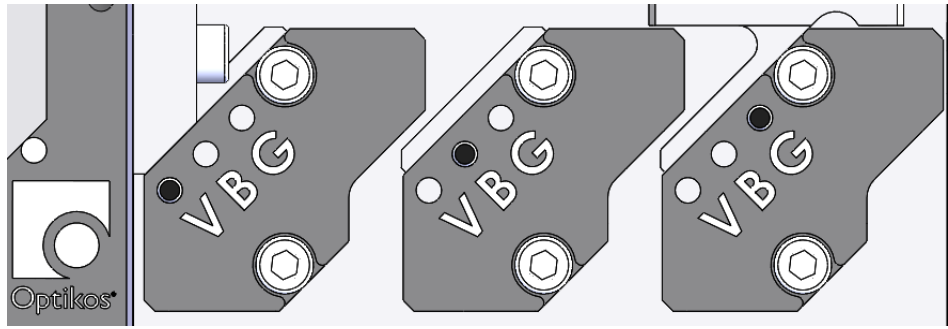
- Prototypes may benefit from additional features or capabilities
- In this example, we'll assume that two light sources may be desirable to test
- Leaving space for additional light source components in the system layout allows these to be easily added later



Design For Prototyping Example (Leveraging Modularity)

- Some examples of modular beam-splitters and beam-combiners
- Multi-wavelength systems can benefit from identical mounts fitted with different dichroic combiners
- This is where the lockout pin and identifier marking can be useful



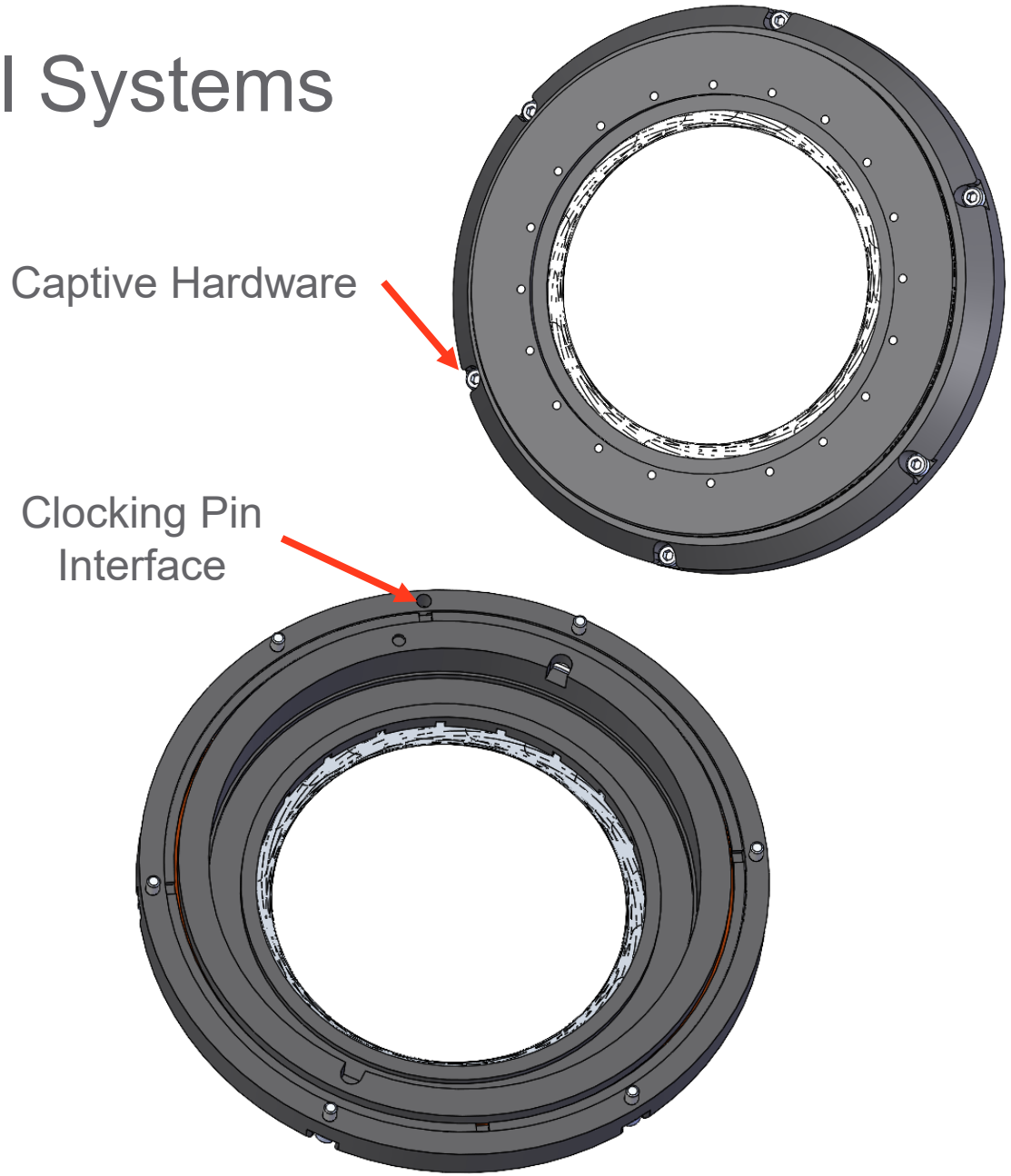


Design for Service (DFS) – Optical Systems

- Key attributes for DFS
  - Modular Components
    - Implement self-aligning or repeatable modular interfaces
    - Group components into sub-systems
  - Ease of access
    - Provide easy access to serviceable components
    - Reduce assembly errors with clear or distinct markings or add error-resistance
  - Design for Fault Tolerance
    - Implement designs that can partially or fully function with a failure
  - Use/misuse cases
    - Determine how customers will interact with the product, review data from existing repair logs of similar products

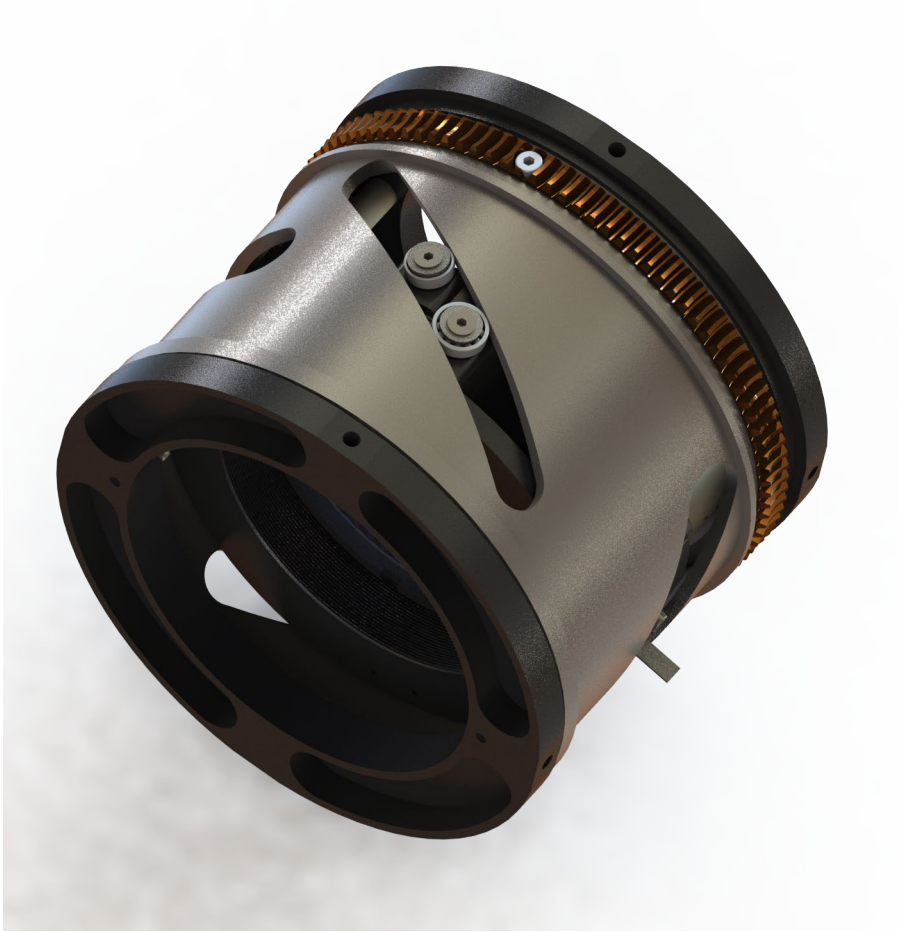
Design for Service (DFS) – Optical Systems

- Modular and serviceable iris assembly
- Captive hardware for ease of user replacement
- Clocking pin prevents incorrect rotational position
- Core module can be re-built (depot service)
  - Wear items include bearings and iris blades
- Optical system architecture places this assembly out front (very easy access)



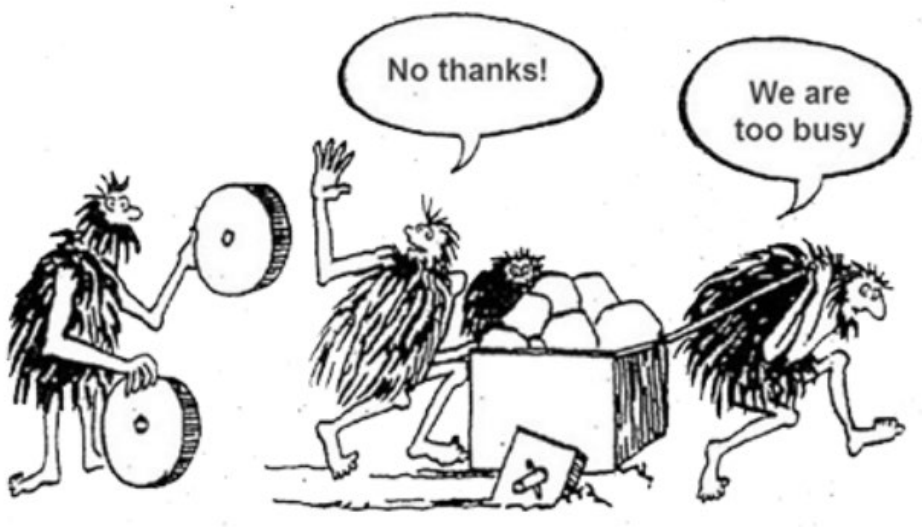
Design for Service (DFS) – Optical Systems

- What about captive assemblies?
  - Captive focus assembly example
- Fault tolerance can be an important design consideration
- In this case, bearings can fail or seize
- There is sufficient margin in drive force to enable sliding contact in the cam mechanism
- The cam ends are supported by bearings, again with clearance to enable sliding contact



Frequently Encountered Excuses to Not Apply DFX

- No time
- Not invented here
- Blueprint/prototype bias
- Low assembly costs
- Lower volume
- We've been doing it for years



Closing Remarks

- The intent here is to start thinking about DFX early in a development effort
- Ideally, limit the ‘X’ to one or two key parameters
- Even during a prototype development, DFX can provide advantages (ease of testing, reduced effort for follow-on development efforts)
- When in doubt with optical systems, design components to be modular

Thank You
&
Questions

Nathan Wallace nwallace@optikos.com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