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DFX in Action: Modular Strategies for Optical Systems

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Overview

- DFX and its value with developing optical systems
- Applying DFX to an optical system manufactured in moderate volumes
- Applying DFX to a prototype optical system
- Closing remarks

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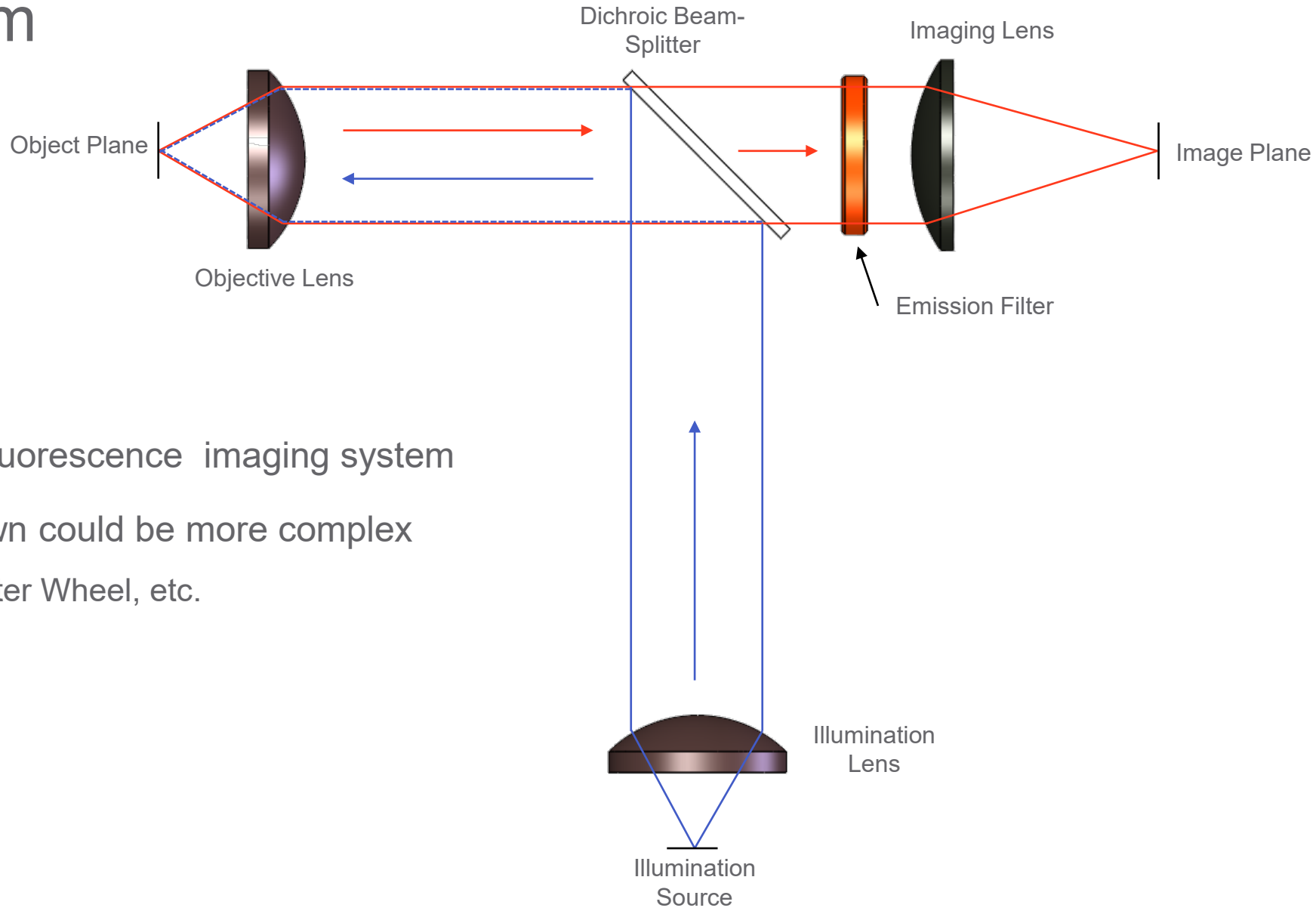
What is DFX?

- 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 has more value when applied very early in a development effort

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The Optical System



- High-level layout of a typical fluorescence imaging system
- Many of the components shown could be more complex
  - Objective Lens, Tube Lens, Filter Wheel, etc.

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Where To Start With DFX

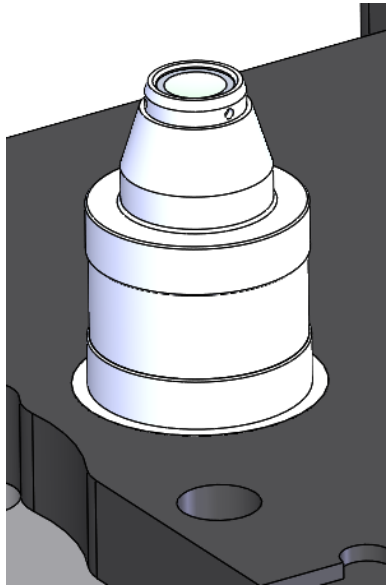
- Start with high level product needs
  - Is there cost sensitivity?
  - Is reliability or service important?
  - Is performance the key product driver?
- Generate a matrix and list the DFX principles that apply
- Finally, produce a list of design implementation areas that can be prioritized by the development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

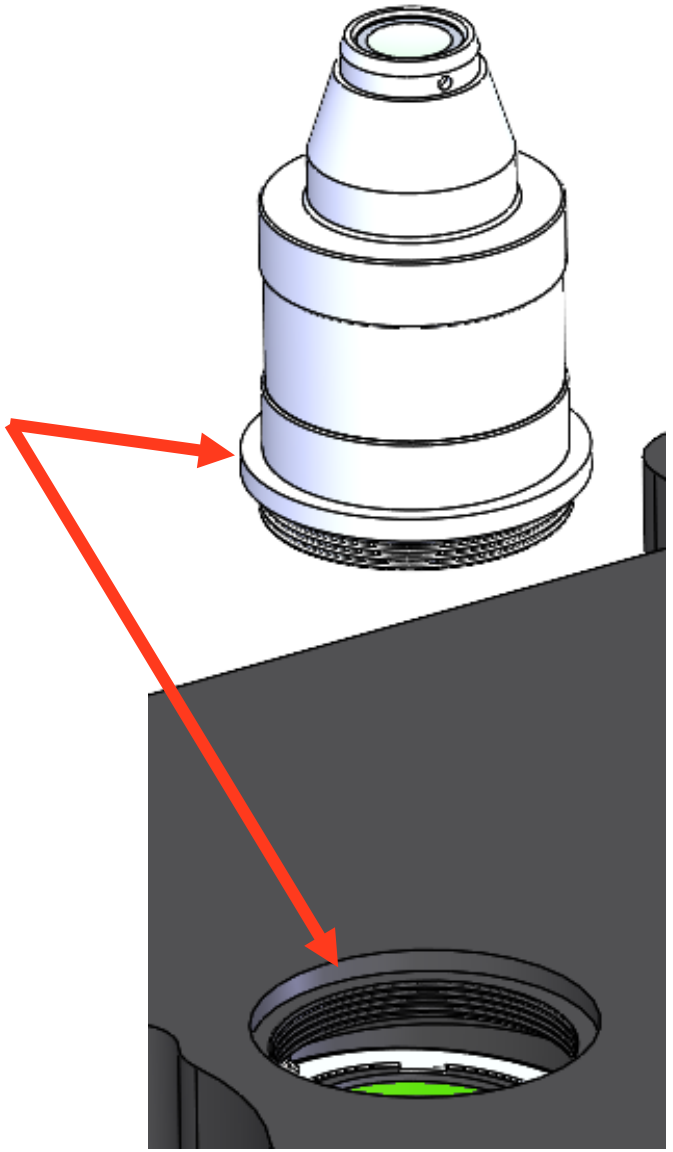
Customer Need	DFX Principle	Design Implementation Examples
High optical performance	Design for Performance (DFP)	Minimize aberrations, ensure high resolution or throughput, and add compensators to recover performance
Low manufacturing cost	Design for Manufacturability (DFM), Cost (DFC)	Use standard optics, 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

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Design For Manufacturing (DFM) Example

- Alignment challenges for objective lens
- Controls angular and centration errors without relying on thread accuracy
  - 25um diametral allowance gives 12.7um centration
- Modular approach, easy to swap, does not require heroic tolerances for consistent performance

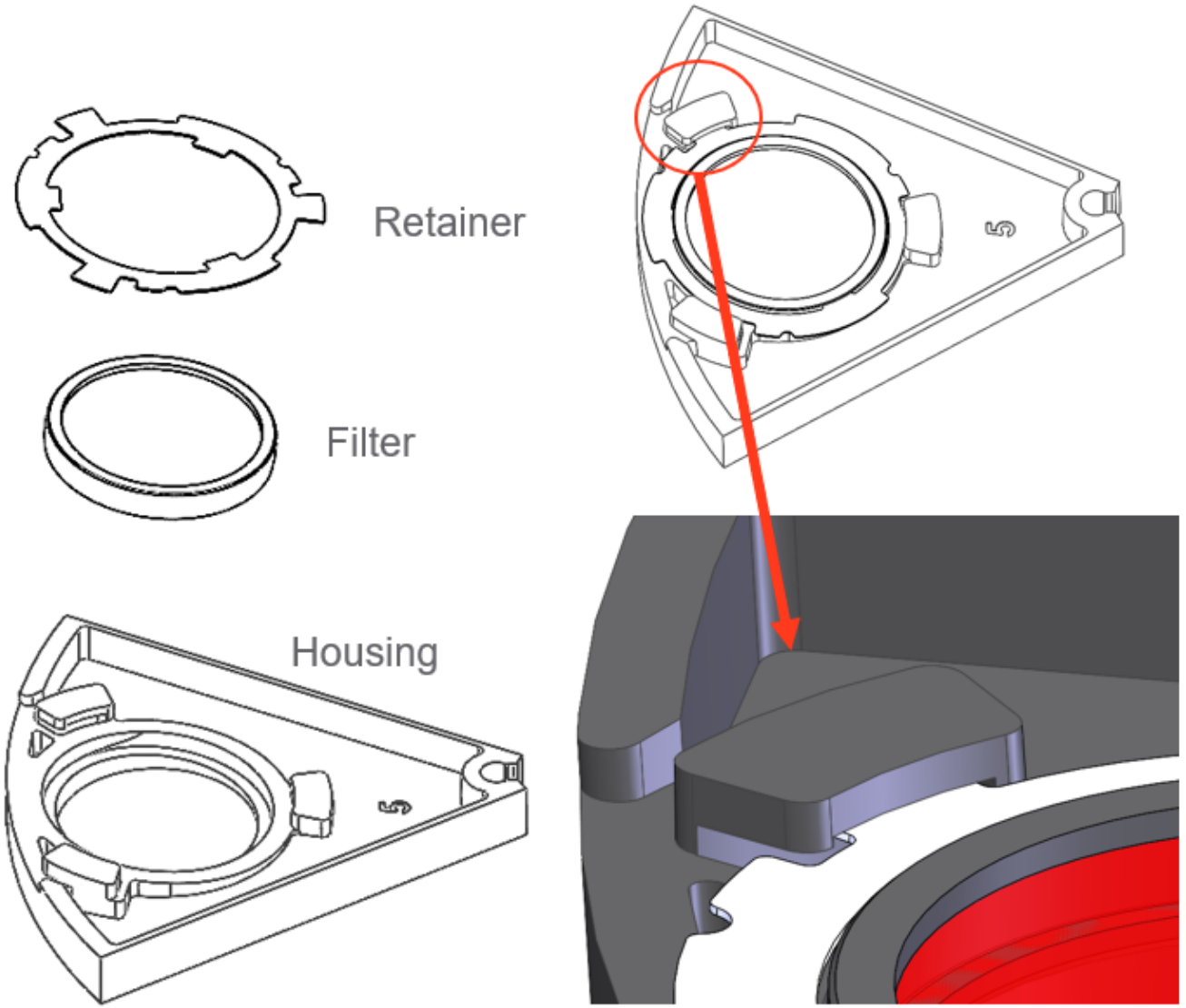




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Design For Manufacturing (DFM) Example

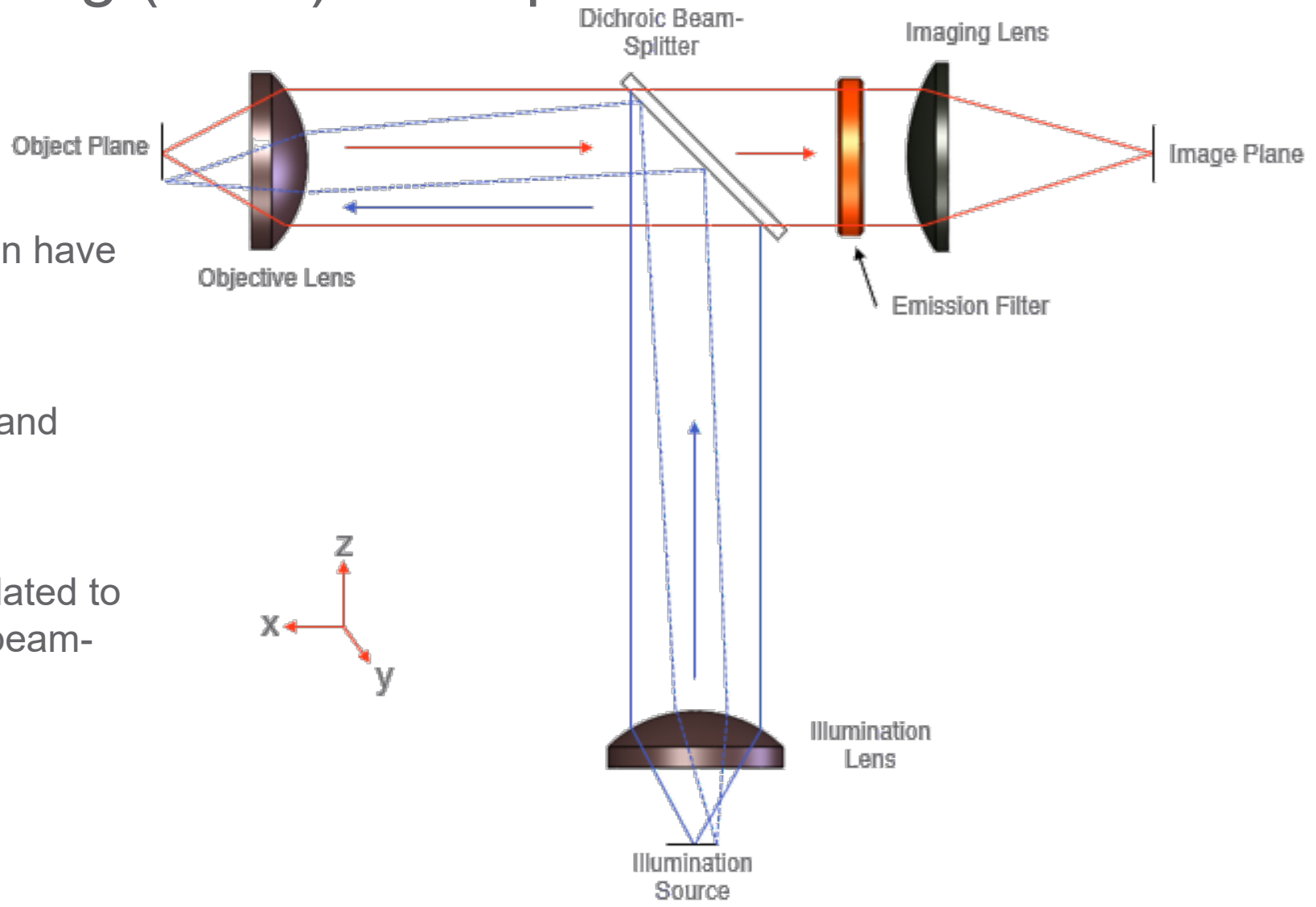
- Injection molded filter housing
- COTS filter (ring mounted)
- Photoetched stainless steel retainer
- Eliminates traditional fasteners
- Ease of installation with custom spanner tool



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Design For Manufacturing (DFM) Example

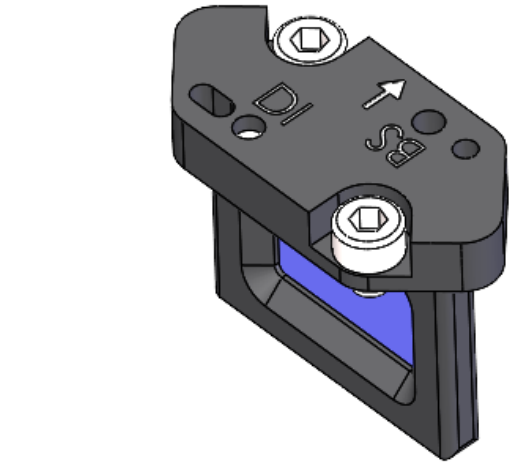
- System level alignment strategies can have a large impact on manufacturability
- Rather than align every component, calculate errors from hard mounting and push the required alignments to one component if possible
- The illumination source can be translated to accommodate angular errors in the beam-splitter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

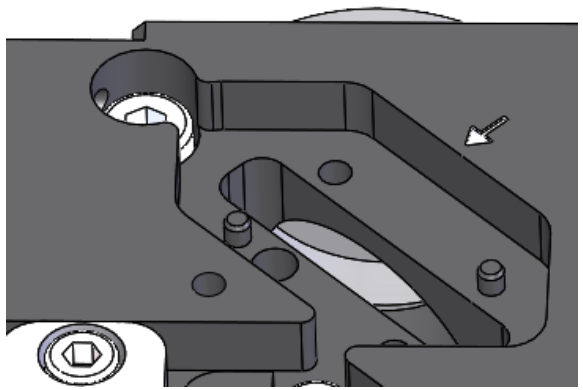


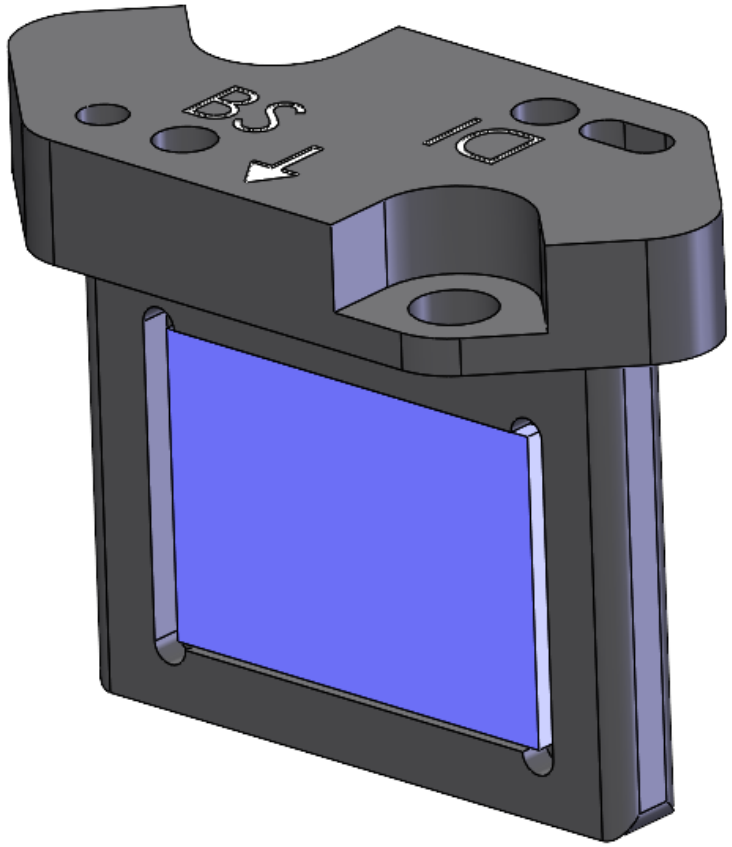
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Design For Prototyping Example (Leveraging Modularity)

- 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



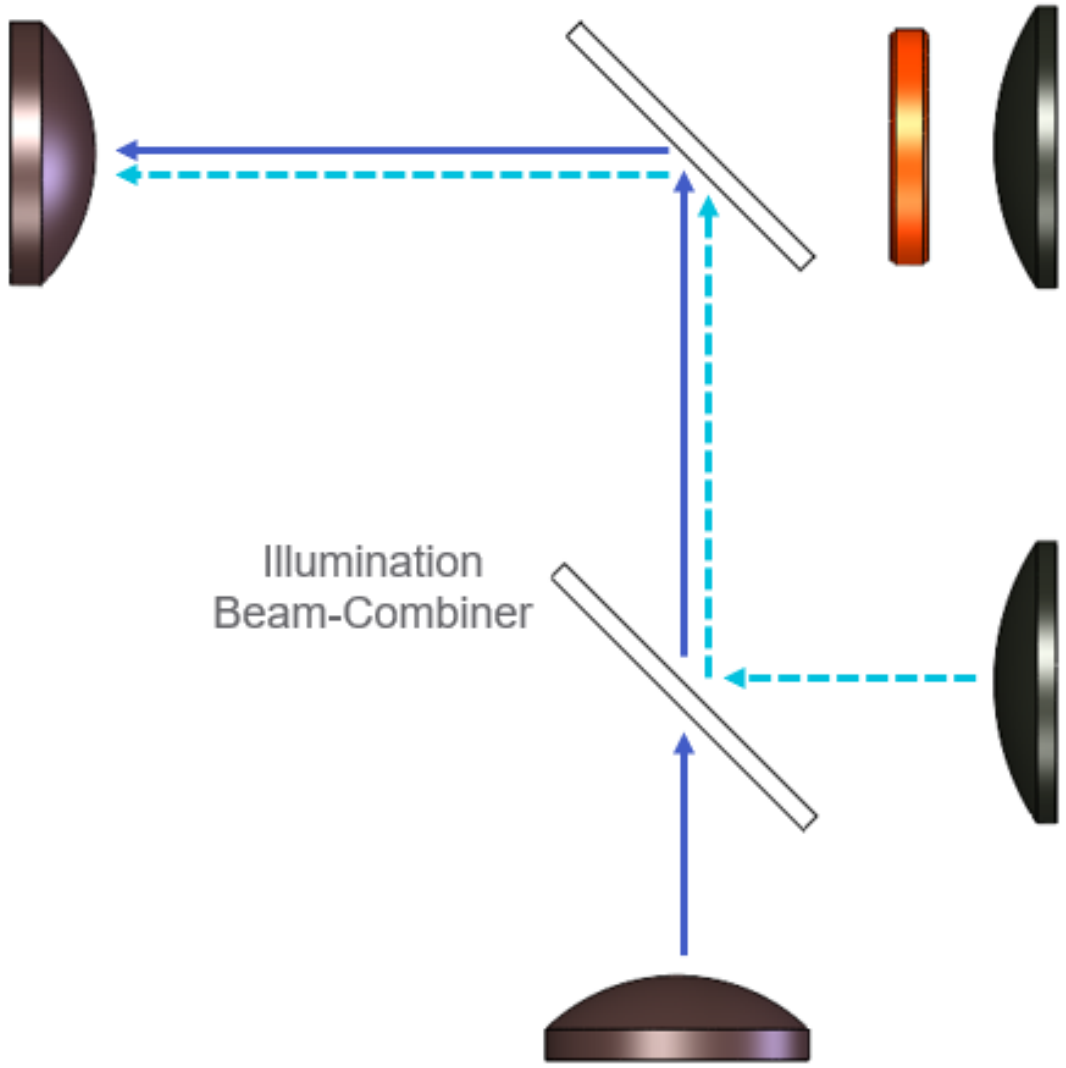




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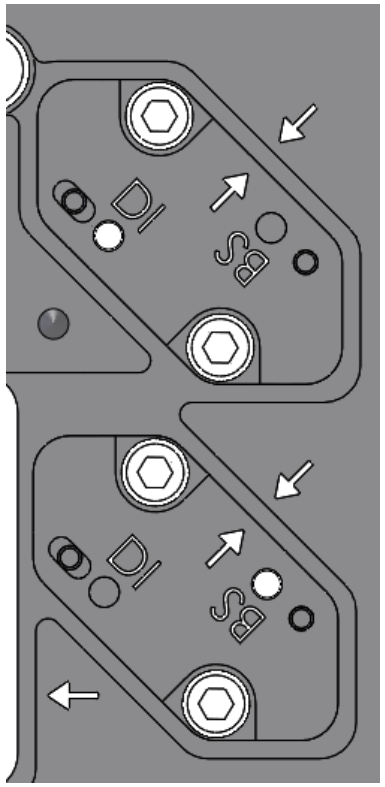
- Prototypes may benefit from additional features or capabilities
- In this example, we'll assume that two light sources may be desirable to test
- Leaving space for additional light source components in the system layout allows these to be easily added later

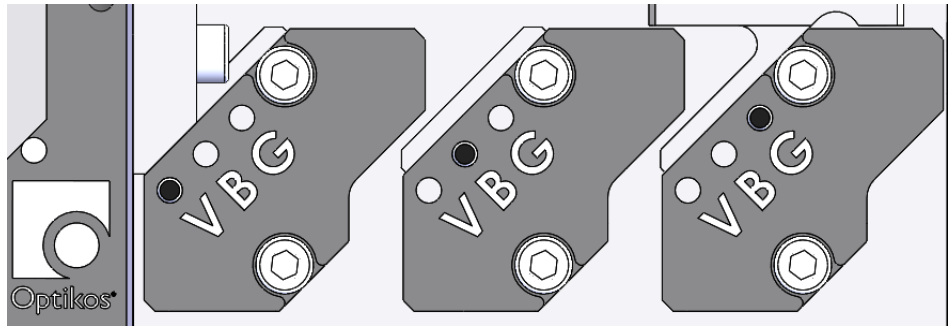


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Design For Prototyping Example (Leveraging Modularity)

- 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





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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, design components to be modular

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Thank You
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Questions

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