CFE Services

Integrating S/W Tools for Opto-Mechanical Design

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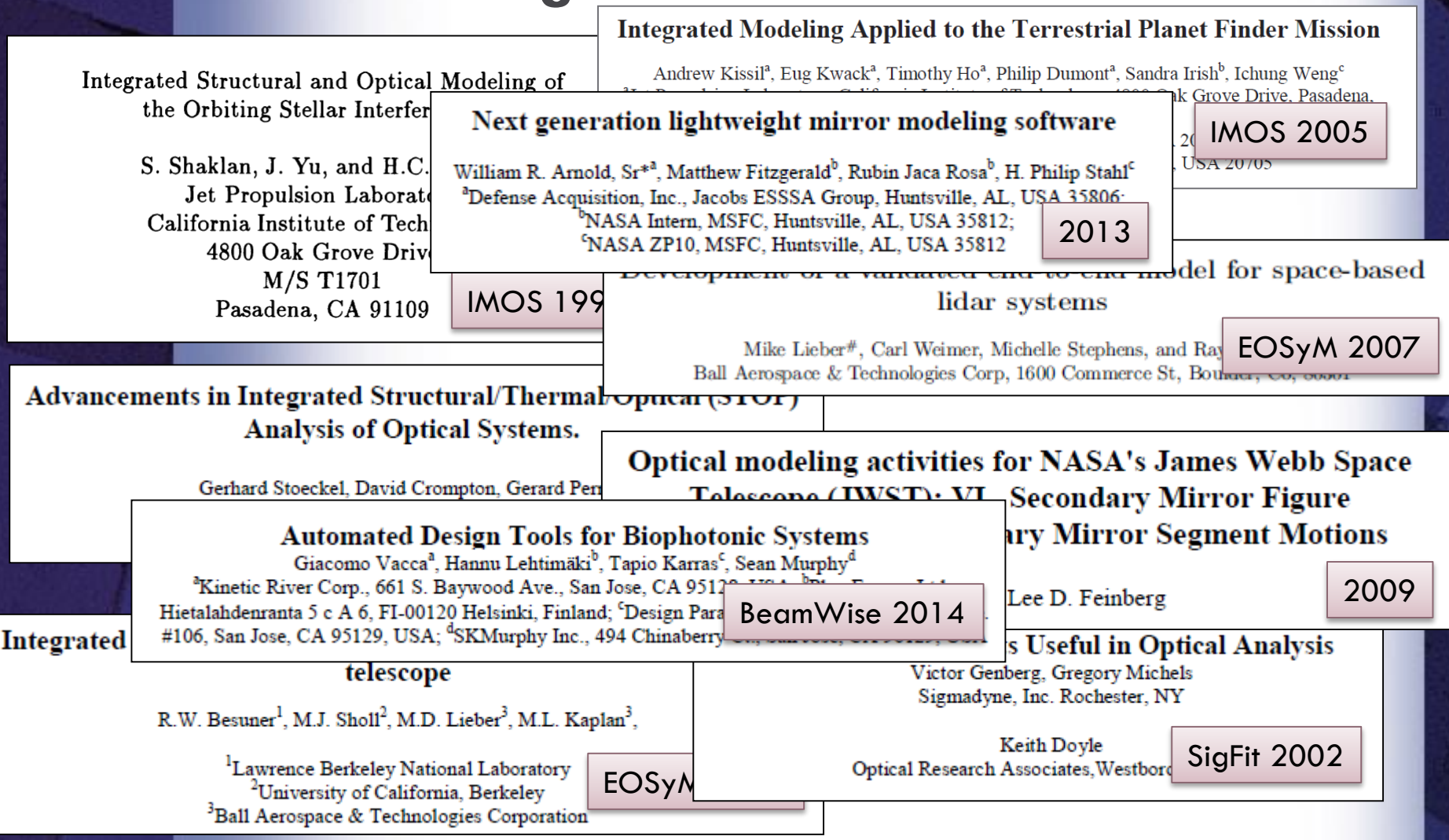
NASA Mirror Technology Days - 2014

Long, Rich Heritage in Integrated Modeling



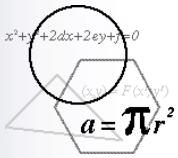
With All These Tools…What is Left?

- Most Tools are Internal
  - IMOS, EOSyM, MACOS, et al.
- Notable Exceptions
  - SigFit, BeamWise, and some primitive tools
- Necessity is the Mother of Invention
  - Several SBIR's Drove Creation of Tools to Help the Engineering Process
  - Avoid Errors (and Tedious Work)
- Started Working with API's… Here's What I Found

Case Studies

- Matlab Design to Optical Design
  - Matlab / Zemax / FRED
- Linking Optical Design with Strain Analysis
  - Nastran / Matlab / Zemax
- CGH Design with SolidWorks
  - C# / Java / SolidWorks

Matlab Driven Design



- Architectural Trade Space
- Analytical Expressions

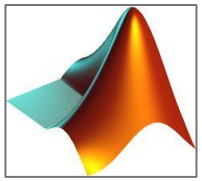
Conceptual Design

Optimize Concept

- Render Layout
- Optimize Architecture
- Transfer to Ray Trace

- Establish Merit Fn
- Create Performance Metric
- Optimize Sub-Space

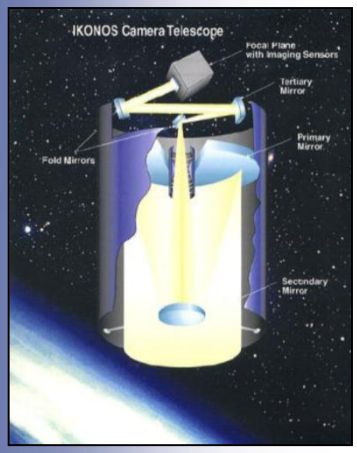
Optimize Performance

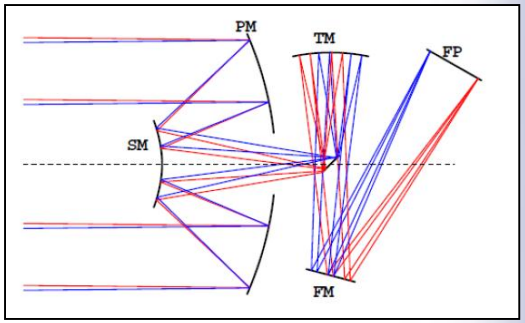


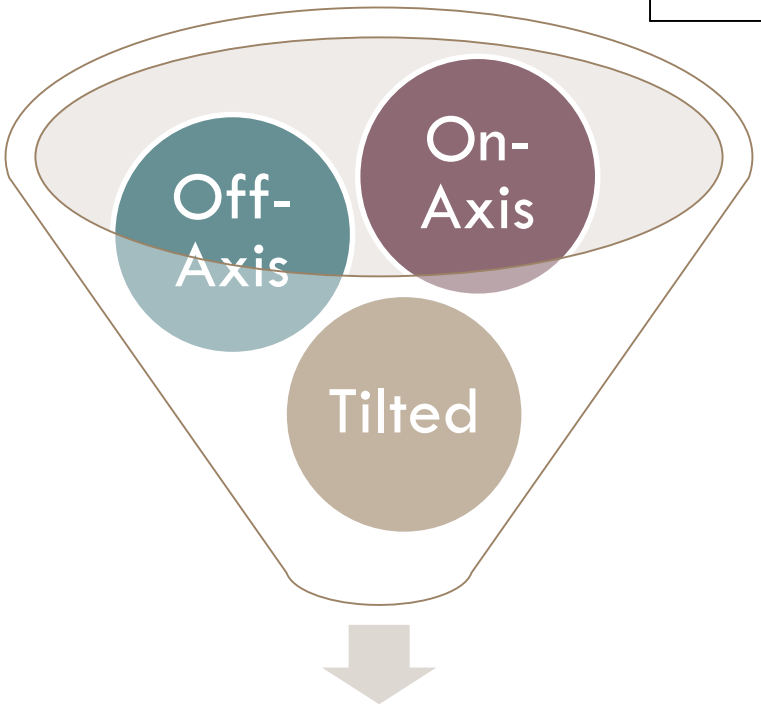
Zemax

Photon ENGINEERING
Illuminating Ideas

Case Study: TMA





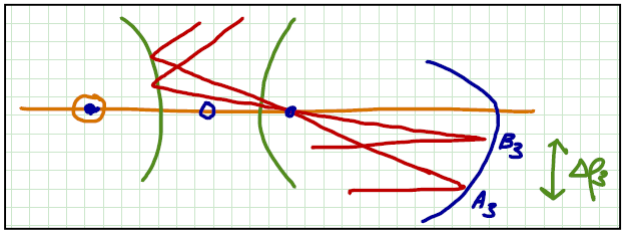


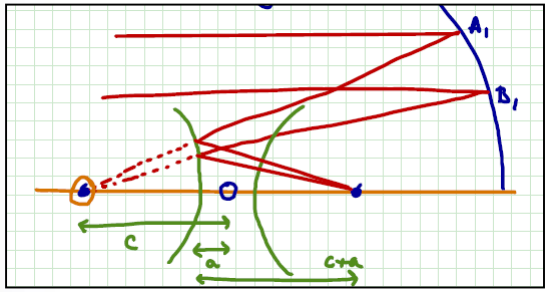
Trade Study: Compare and Down Select

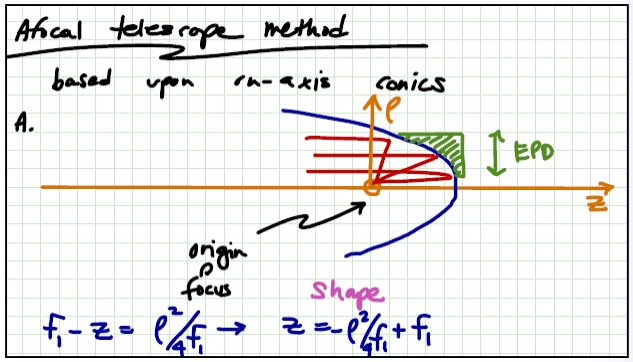
Create Analytical Relationships

- Model: Basic Conic Surfaces

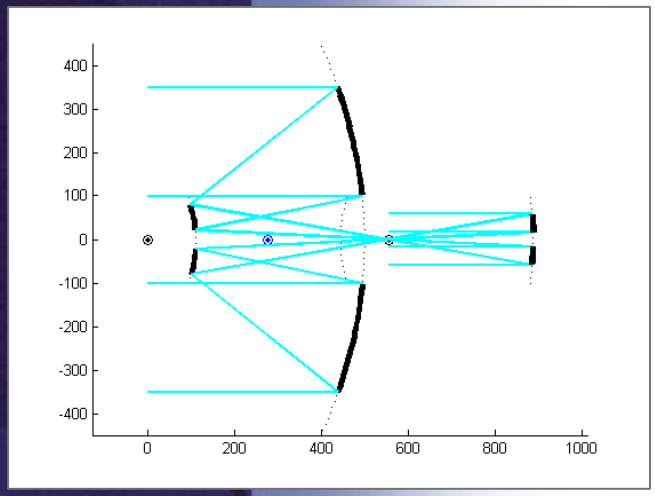
- System Level Parameters
  - Off-Axis Distance, Tilt Angles, Distances, Magnification

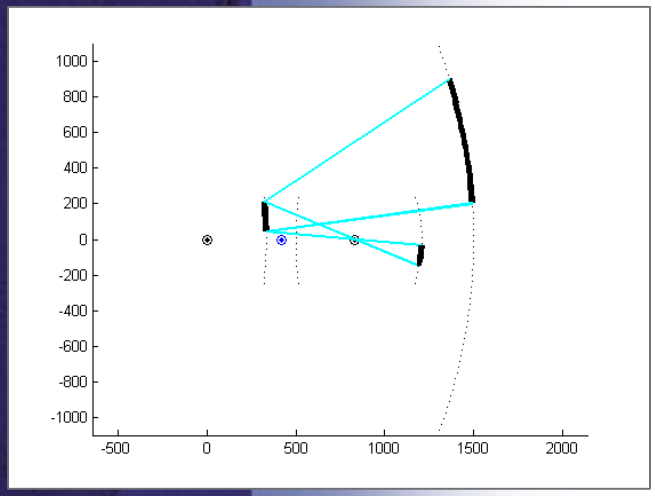






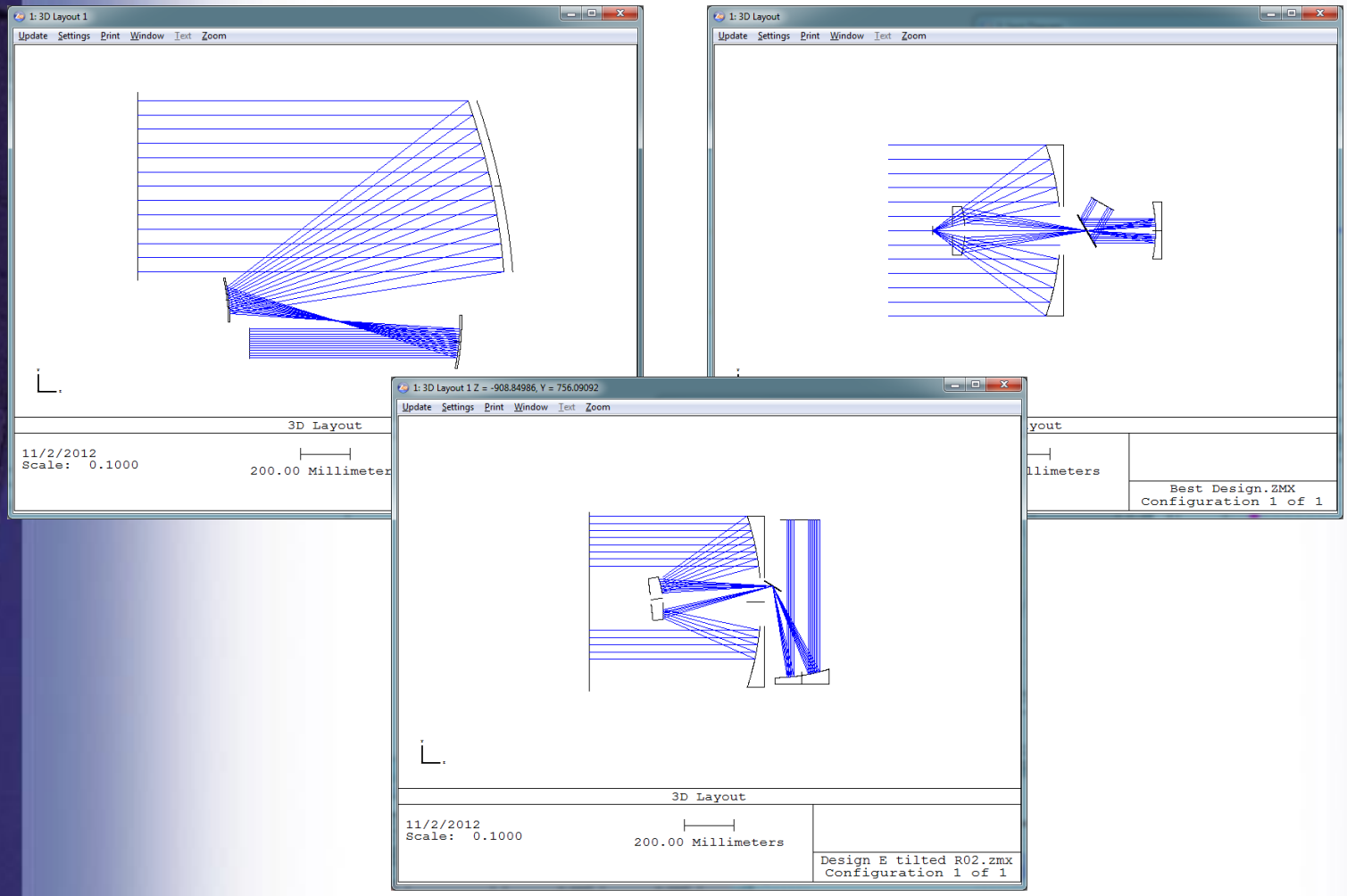
Exercise Model in Matlab



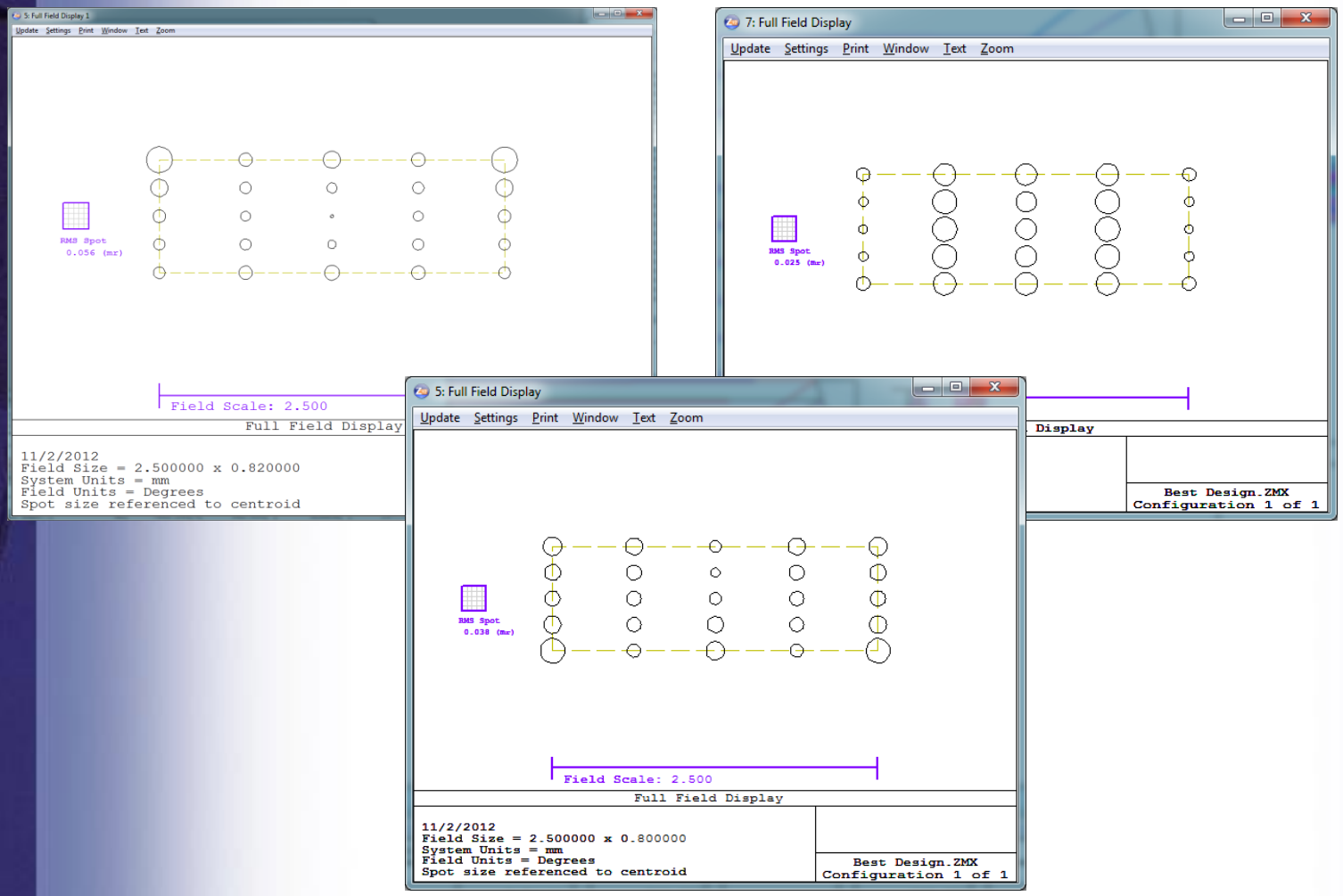


- Object Oriented Programming
  - Classes w/ Methods + Properties
  - Encapsulation + Polymorphism
- Render Surfaces
  - Foci, Marginal Rays, Common Axis, Origin, Vertex
- Inspect Obscuration
- Export to Zemax
  - Push to Zemax
  - Radius of Curve, Conic Constant, Distances, Aperture Size

Optical TMA Models

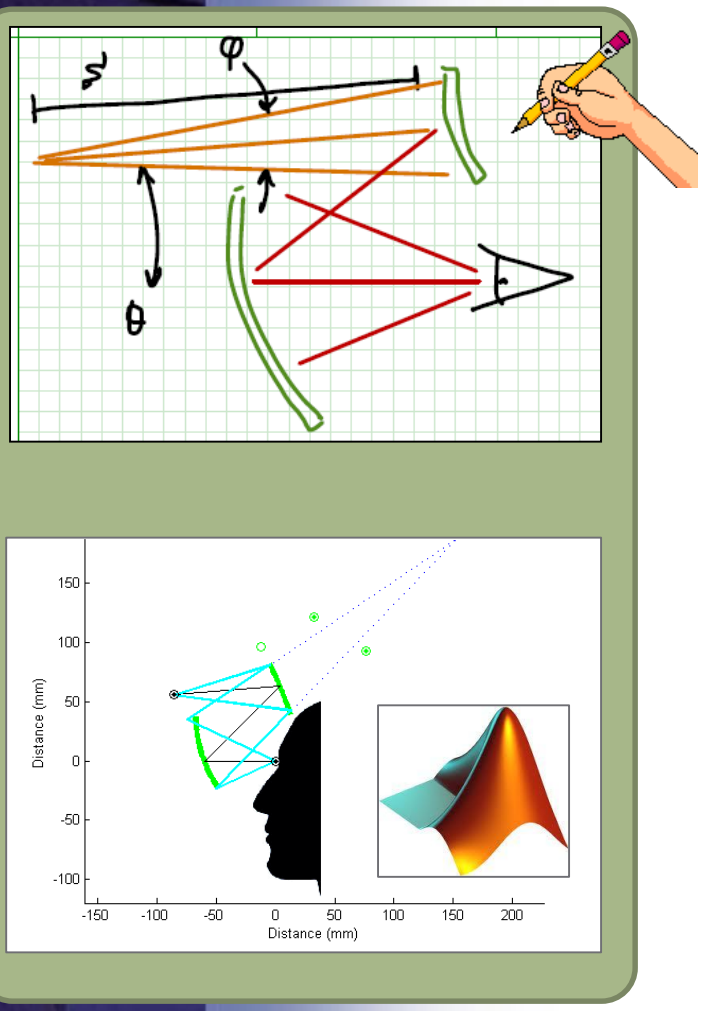


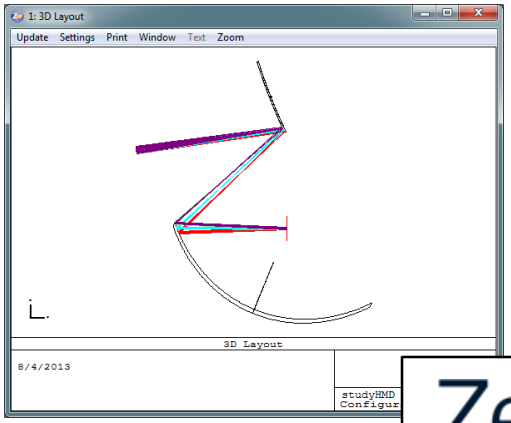
Performance / Full Field Display*

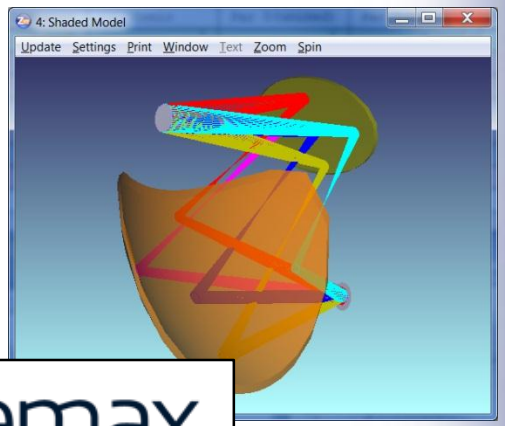


*Custom Zemax Extension DLL

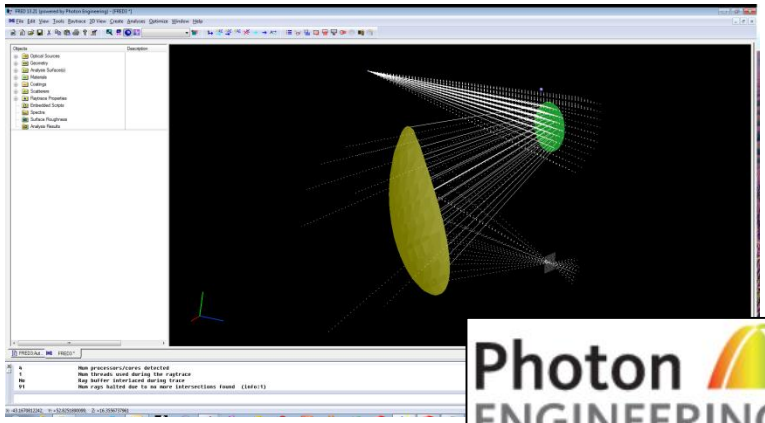
Case Study: Two Off-Axis Mirrors





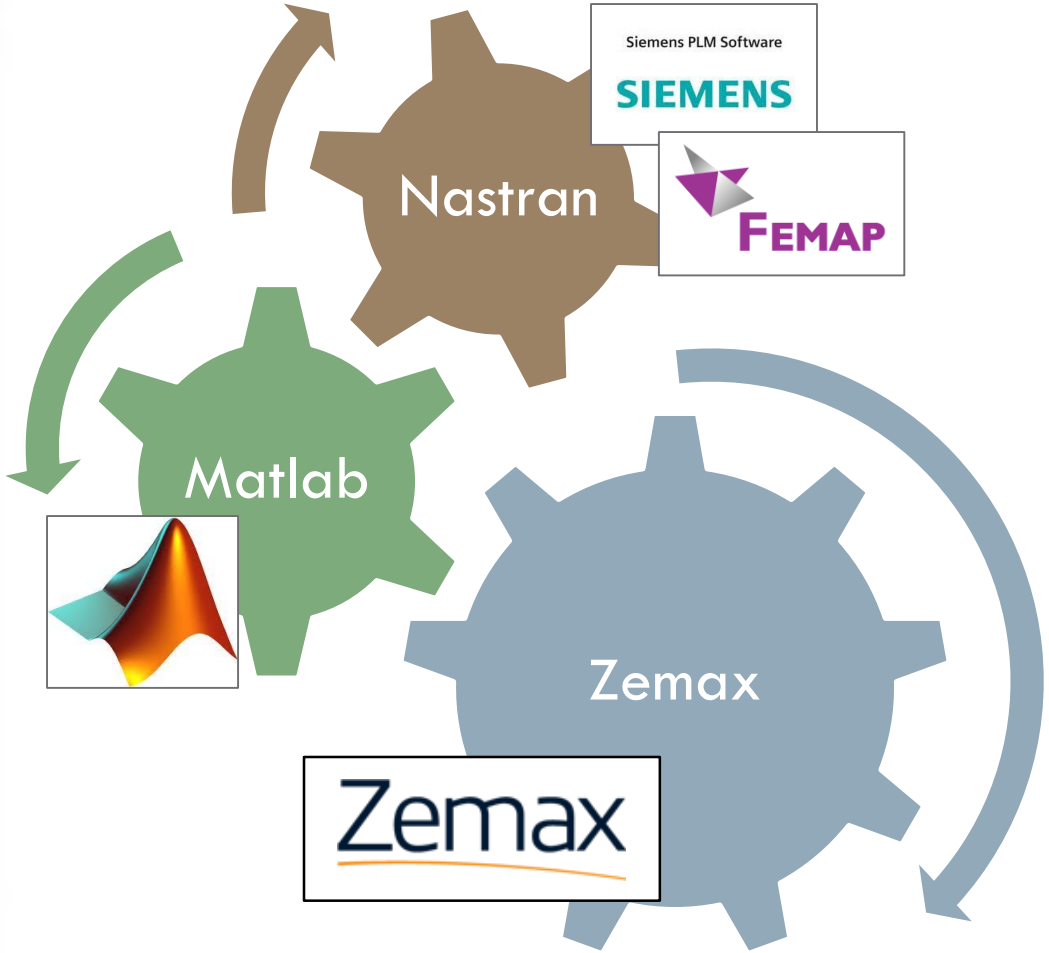


Zemax

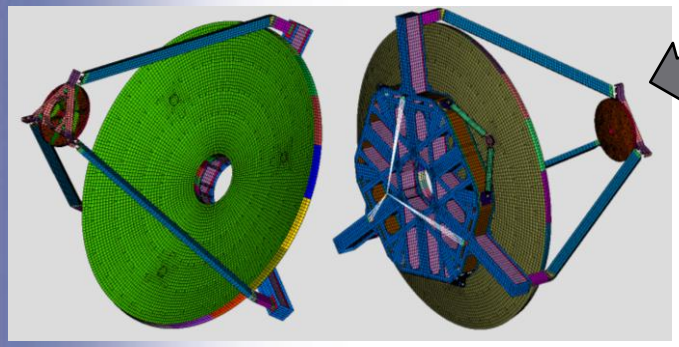


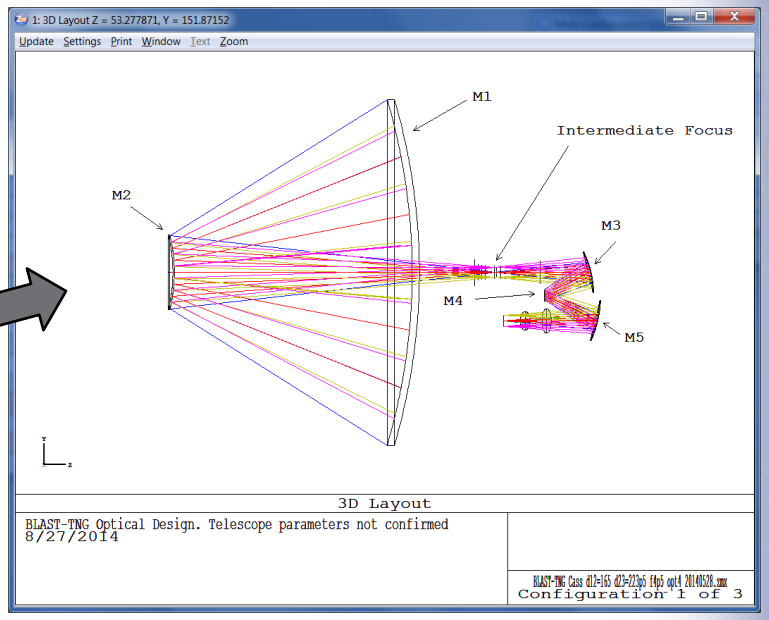
Photon ENGINEERING
Illuminating Ideas

Case Study: Linking Zemax and Nastran



BLAST Goals





- Lightweight CFRC Telescope
  - Structurally Efficient
  - Balloon Borne Temperature Environment
  - Pointing from near Horizon to near Zenith
- Support Development of Mechanical Structure
  - Rapid Turn Around WFE Evaluation
  - Evaluate PSF / WG Coupling

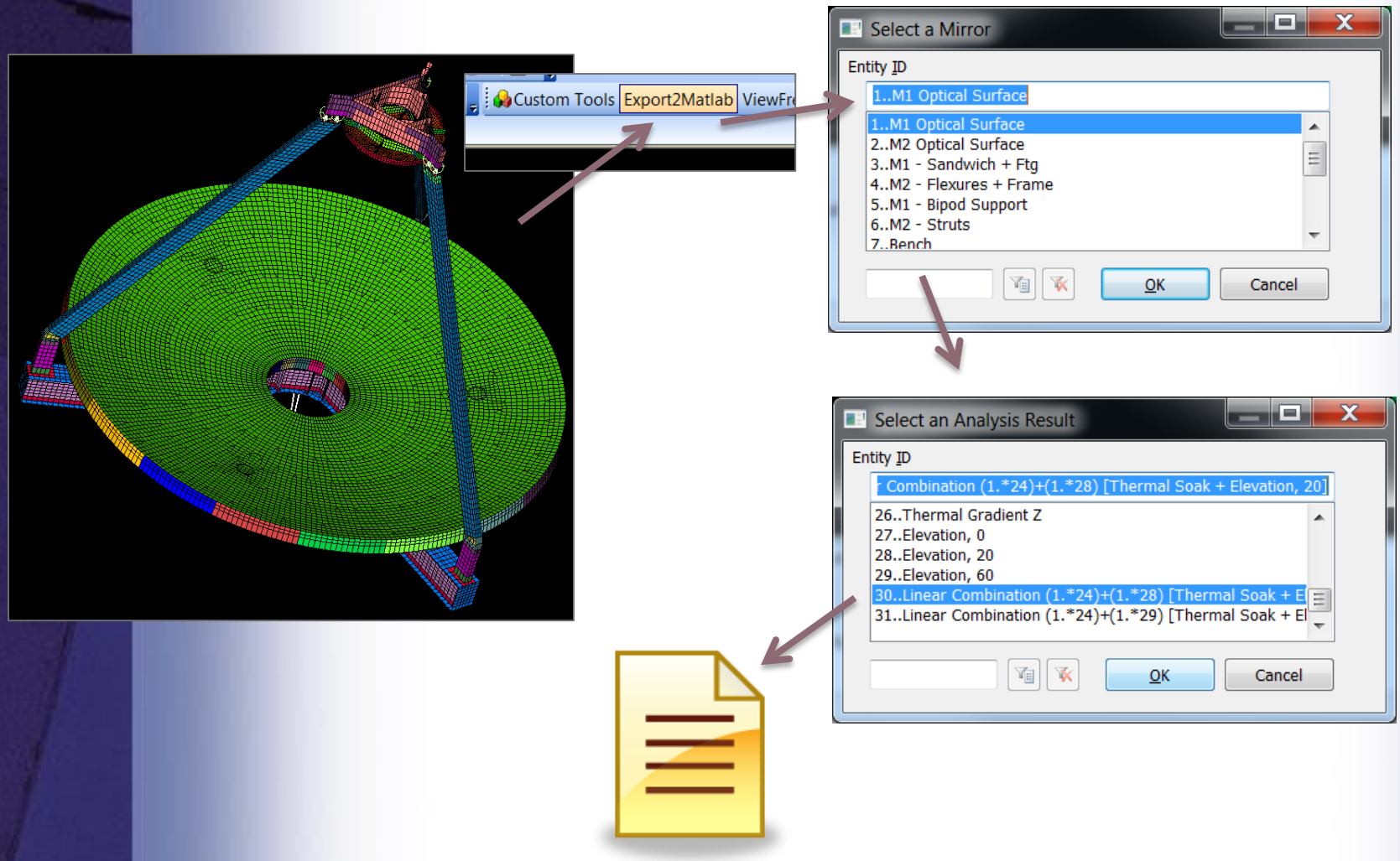
WorkFlow for BLAST

1. Push Button Export from Femap

2. Best Fit
   - Rigid Body, Optical Rx (RoC, Conic)
   - Zernike + Residuals

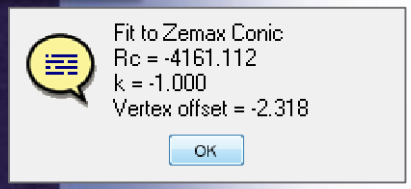
3. Data Output
   - Femap for Structural Improvement
   - Zemax for PSF Evaluation

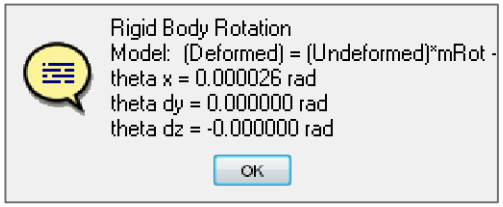
Femap / Nastran Export

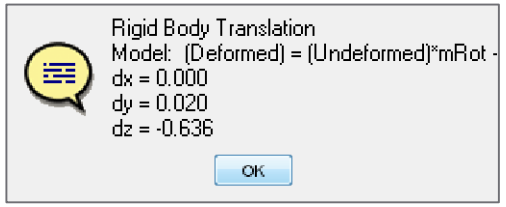


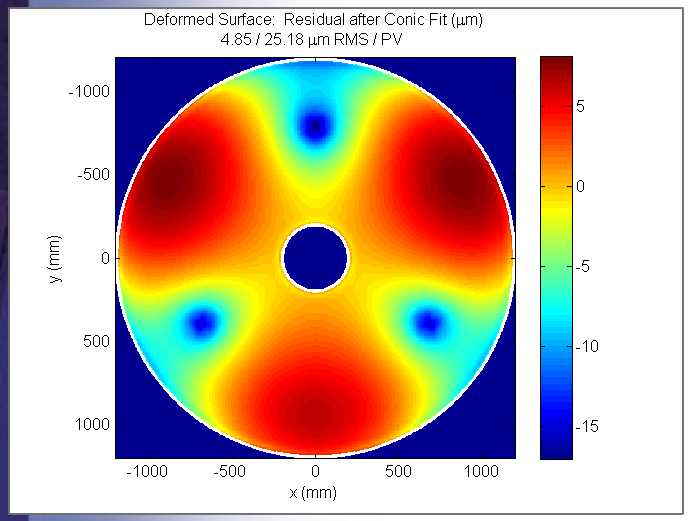
Analysis of Surface

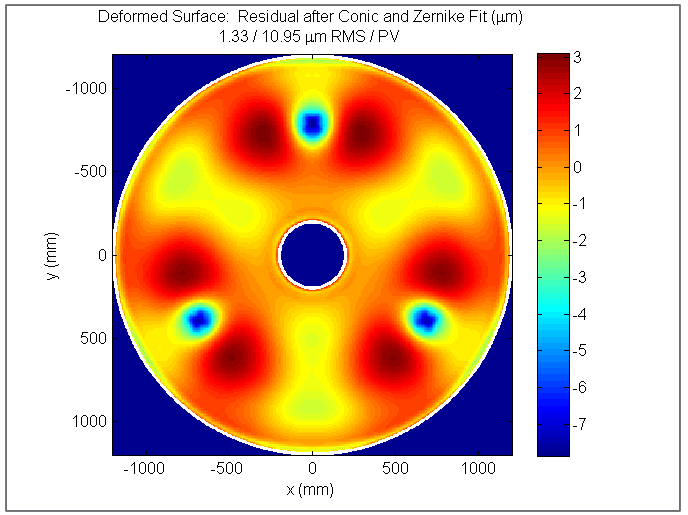
Rigid Body Fit







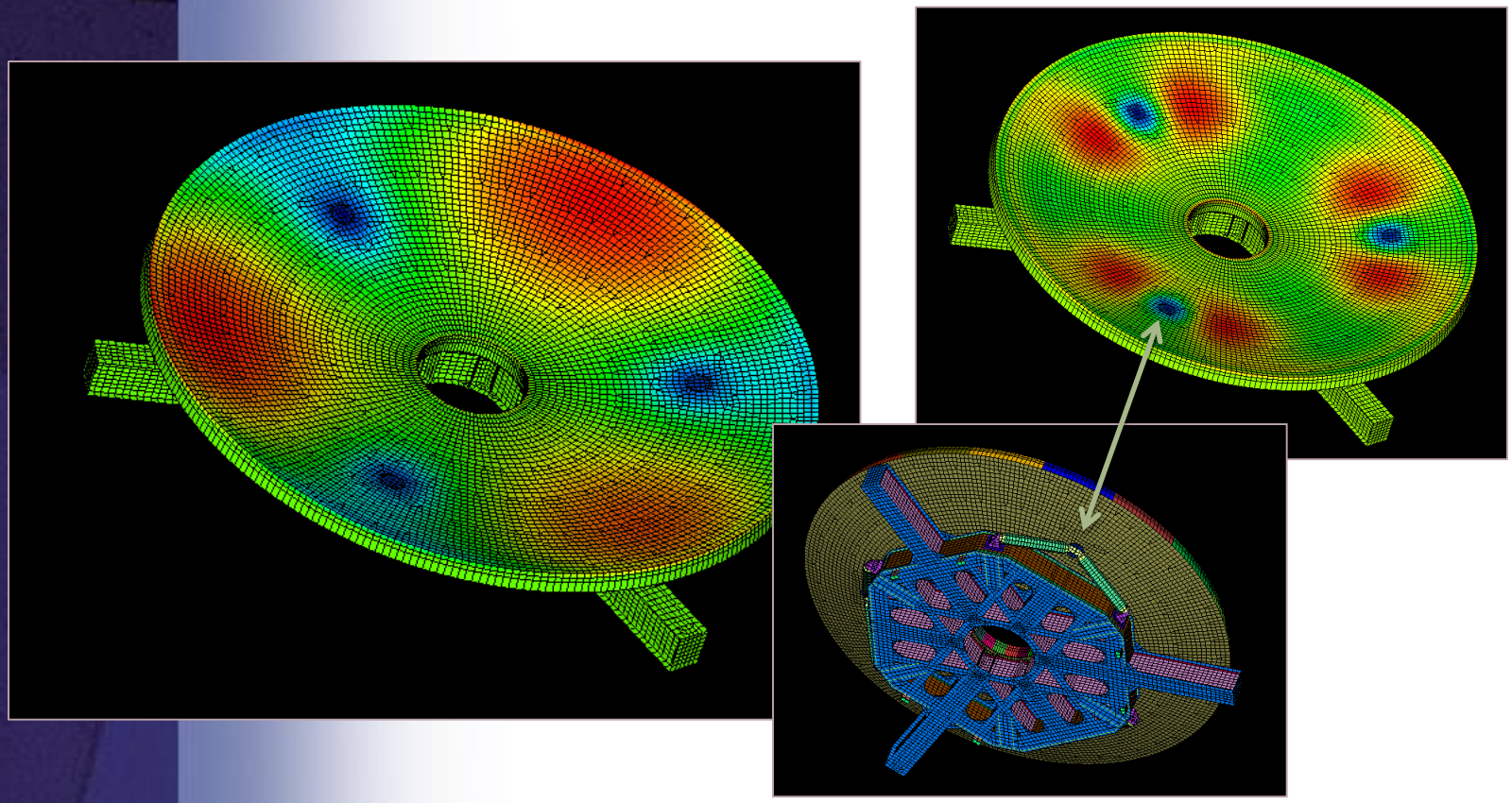




$$W_{Aberr} = W - W_{conic}$$

$$W_{non-Zern} = W_{Aberr} - W_{Zern} = W_{Aberr} - \sum_{i=1}^{36} A_i \cdot Z_i(x, y)$$

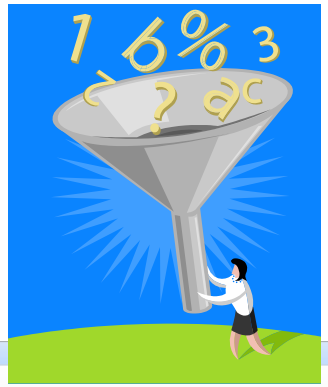
Pull Into Nastran



- Correlation Between Aberrations and Structure more Clear in Femap

Push to Zemax

- Using DDE, Data Directly Pushed into Zemax



Lens Data

Surface 7 Properties

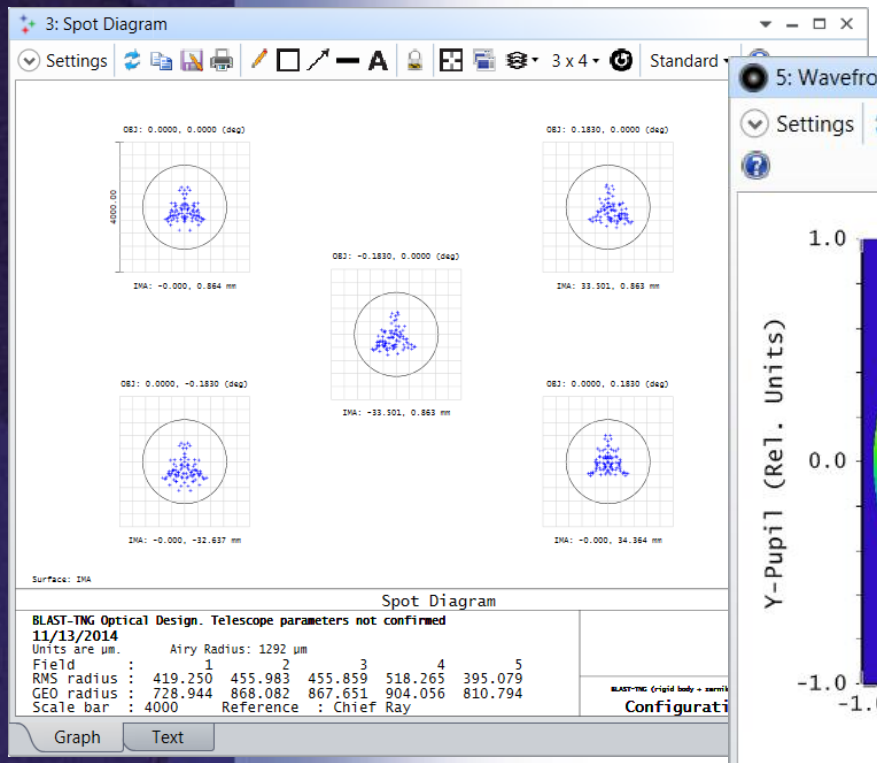
	Surf:Type		Comment	Radius	Thickness	Material	Coating	Semi-Diameter	Conic	TCE x 1E-6	Extrapolate	2nd Order Term	4th Order Term	6th Order Term	8th Order Term	10th Order Term	12th Order Term	14th Order
0	OBJECT	Standard		Infinity	Infinity			Infinity	0.000	0.000								
1		Coordinate Break	rot th		.581	-		0.000		-		2.487E-006	-(			0.000	1	
2	STOP (aper)	Zernike Fringe Sag	PRIMARY		.000	MIRROR		1250.000 U	-1.003	0.000	1	0.000	(			0.000	0.000	0.0(
3		Coordinate Break			.581 P	-		0.000		-		-2.487E-006 P	(			0.000 P	0	
4		Standard			.000			9.999	0.000	0.000								
5		Standard	Seconda	offset	Infinity	0.000		7.402	0.000	0.000								
6		Coordinate Break			-3.356	-		0.000		-		3.503E-005	-0.479	8.928E-003	0.000	0.000	1	
7	(aper)	Zernike Fringe Sag	SECONDARY(	85 C)	-1065.296	0.000	MIRROR	258.110 U	-2.183	0.000	1	0.000	0.000	0.000	0.000	0.000	0.000	0.0(
8		Coordinate Break				-		0.000		-						0.000 P	0	
9		Standard			Infinity	1650.000		7.436	0.000	0.000								
10		Standard			Infinity	430.700		28.084	0.000	0.000								
11	(aper)	Standard	Rec-Filter Surface		Infinity	25.700		90.500 U	0.000	0.000								
12	(aper)	Standard	Window Aperture		Infinity	26.000		53.000 U	0.000	0.000								
13	(aper)	Standard	VCS2 Filter		Infinity	25.400		50.000 U	0.000	0.000								
14	(aper)	Standard	VCS1 Filter		Infinity	59.700		47.500 U	0.000	0.000								
15	(aper)	Standard	4K Filter		Infinity	17.500		45.000 U	0.000	0.000								
16		Standard	Cass focus		Infinity	-86.430		35.621	0.000	0.000								
17	IMAGE	Standard			Infinity	-		34.368	0.000	0.000								

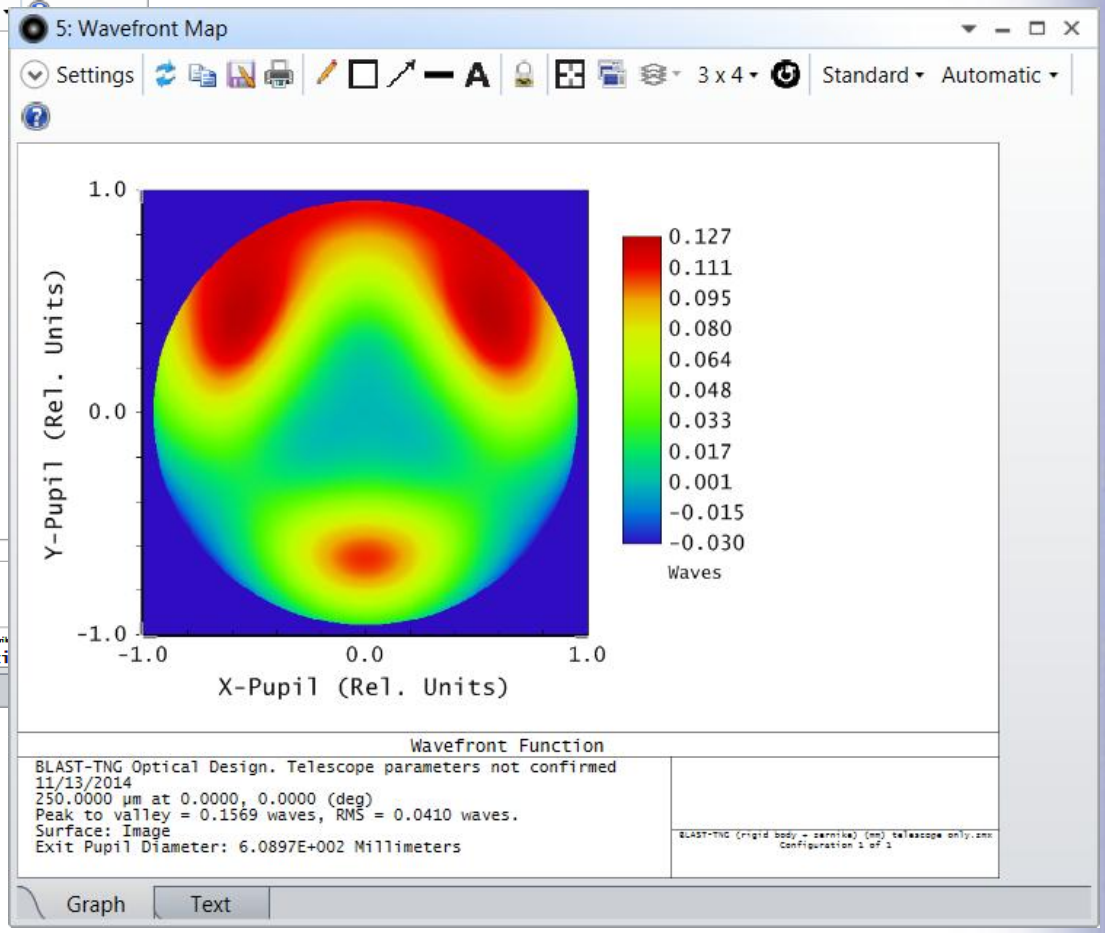
Rc + k

Rigid Body

Zernikes

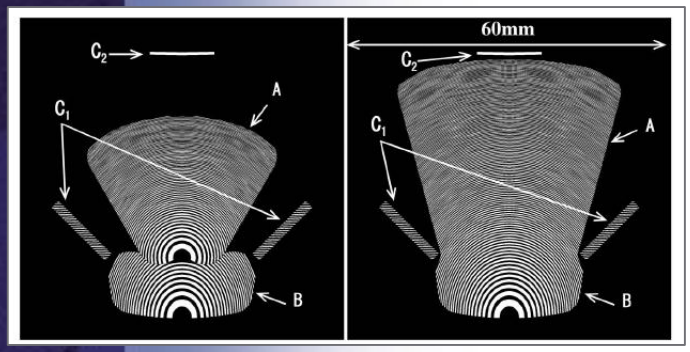
Optical System Performance

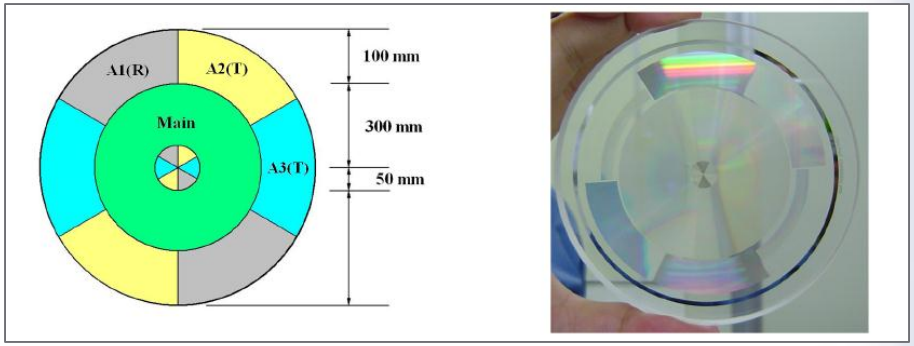




Case Study: CGH Design

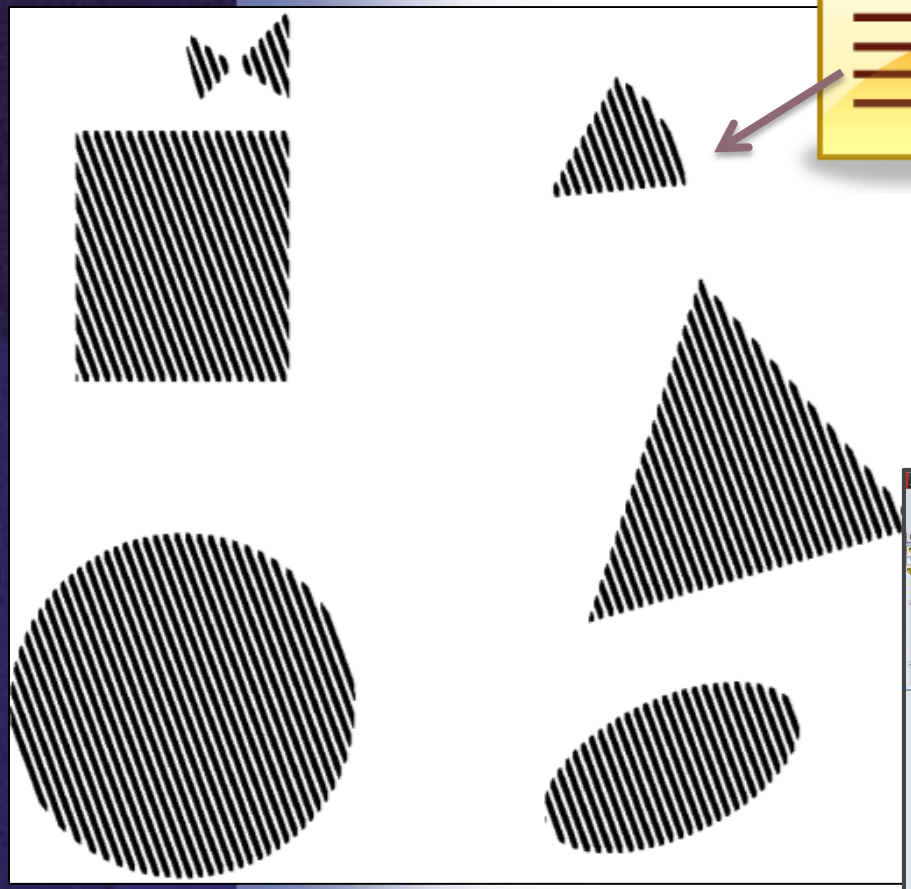
- Applications in Optical Metrology and AI/T
  - Require Complex Apertures
  - Precisely Aligned Fiducials

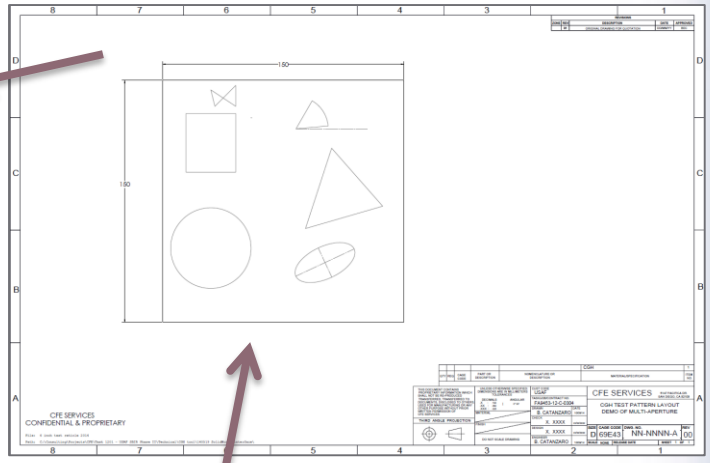


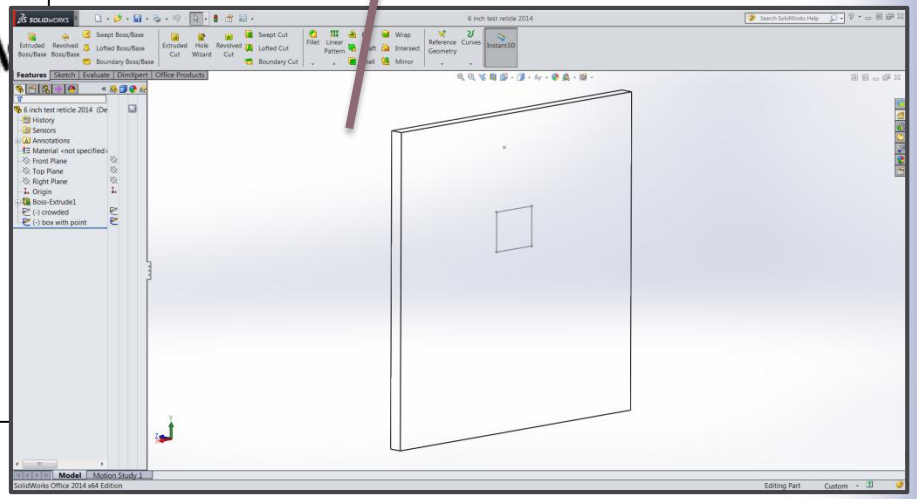


Write Your Own GUI?
Open Source GUI?
Leverage Commercial Design Software?

Parametric Mechanical Layout for CGH







After this Journey, Lessons Learned

- Working with API's is Not that Hard
  - Modern S/W Lifted Much of the Burden
  - OOP (Java, C#) + Testing Frameworks
  - Open Source for Graphics / XML / MySQL
- Don't Reinvent the Wheel
  - Interfacing is more Value Added than Writing Your Own Code
- Engineering Interface Standard is Needed
  - Won't Necessarily Come from S/W Industry
- CAD Frees Your Mind for Higher Work
  - One S/W to Rule them All?
  - App's?