Zemax

Structural Thermal Optical Performance (STOP)
Outline

• Purpose of STOP
• Current workflow (as we understand it)
• Our proposed solution
• Benchmarking
• Next steps
Purpose of STOP

(Taken from https://tfaws.nasa.gov/files/TFAWS2015-SC-STOP-Analysis.pdf)

STOP analysis estimates the performance degradation of an optical system due to structural and thermal loading

• Possible objectives
  • Create or verify system engineering budget allocation for given thermal loading
  • Stress/Deflection responses to address load capability of the structure
  • Final performance estimate for programs with incomplete ground testing, such as JWST

• Typical quantities predicted
  • Mirror surface distortion
  • Structure distortion and stress
  • System wavefront and pointing error due to optics motions (rigid-body)

• Cyclical in nature and applied at various phases during the design cycle with various levels of model maturity
STOP Council

• We have created a user council to ensure that we are developing the appropriate solution
  • Consists of customers working heavily with STOP that can share their current processes and pain points with us
• Council has 20+ members, with whom we have conducted interviews and process demos
• Feedback from council members has served as key input into the development of the product roadmap for the STOP module and requirements for version 1
• We will continue to work with the council throughout the product development process
Current workflow

• Generate optical design in OpticStudio
• Export design to mechanical engineering package
• Add opto-mechanical components to the design
• Export full opto-mechanical system to finite element analysis (FEA) tools
  • Structural analysis tools: ANSYS, NASTRAN, Abaqus, ...
  • Thermal analysis tools: Thermal Desktop, FLOWTHERM, THERMICA, ...
• Generate surface deformations, rigid body displacement, and 3D temperature profiles for all system components
• Fit FEA output and import results back into OpticStudio to evaluate effects
Issues with current workflow

• Many tools are required, and users need a good understanding of all tools
• Many levels of manual data transfer are required, making the process error-prone and difficult to troubleshoot
• Users are not always confident in the analysis results
• Overall process is extremely time-consuming
Making it better

• Our goal is to simplify the process:
  • Encourage users to work with LensMechanix to reduce steps required to take the optical design to FEA
    • Continue to improve integration between OpticStudio and LensMechanix
  • A STOP module will be created for bringing the FEA results back to OpticStudio
  • Allows users to close the loop, i.e. move results dynamically between OpticStudio and FEA
    • Provides support for dynamic optimization of systems accounting for structural and thermal loading
STOP module version 1

• In the first iteration of the STOP module, users will need to export FEA results to text files
  • Data required are surface deformations, rigid body displacements, and 3D temperature profiles
  • Zemax will build a solution to automate export from commonly used tools
    • Currently investigating ANSYS, Simulia, Thermal Desktop
    • Solution assumes that FEA tools are populated by results from LensMechanix

• The STOP module will then:
  • Convert surface deformations into a non-uniform grid sag profiles
    • May also support conversion to common polynomial sets, e.g. Zernikes
  • Convert temperature profiles into non-uniform grid index profiles
    • Will also support conversion to (most) GRIN polynomials currently supported by OpticStudio
  • Provide visualization of the raw and fitted data sets
  • Create an updated OpticStudio file that includes the non-uniform sag and index data
    • Will modify OpticStudio to allow any surface to include non-uniform sag and index perturbations
Limitations in version 1

The first iteration of the STOP module will have a small set of restrictions:

- Assumes that users will start with sequential imaging system designs
- Assumes single configuration systems
- Requires users to manually export results from FEA tools and place them in a single location for access by the module
  - This requirement will be lifted for some common tools, as listed previously, assuming that LensMechanix is used to generate the input systems for those tools
    - LensMechanix usage currently supported for SolidWorks and Creo Parametric
  - We will not be able to bring perturbed surface data back into LensMechanix and FEA (i.e. we will not support closed-loop operation)
- Future versions will remove these restrictions, with the goal of automating as much of the workflow as possible
Benchmarking

• To benchmark our first version of the STOP module, we have created several test systems:
  • Singlet lens in a 3-point mount (next slide)
  • Dewar and window
  • Three-mirror telescope
  • Single Gauss camera lens (this slide)
Benchmarking

• For each system, we have completed optical designs and solid models, and are in the process of creating structural and thermal models
  • Want to validate results against known solutions (e.g. analytic expressions for trefoil stress) wherever possible
STOP module development schedule

• Focus in Q1 was on understanding workflow and prototyping fitting algorithms
• Plan to begin technical development this month and launch a Lighthouse program in Q4
• Currently looking for customers that will validate our version 1 feature spec and would be interested in serving as early adopters
  • Need feedback on critical pain points and what’s missing from version 1 feature spec to address them
  • Contact me if you are interested! sanjay.gangadhara@zemax.com