National Aeronautics and Space Administration

Multidisciplinary Topological Optimization of a Mechanical Mount for Thermoelastic Stability

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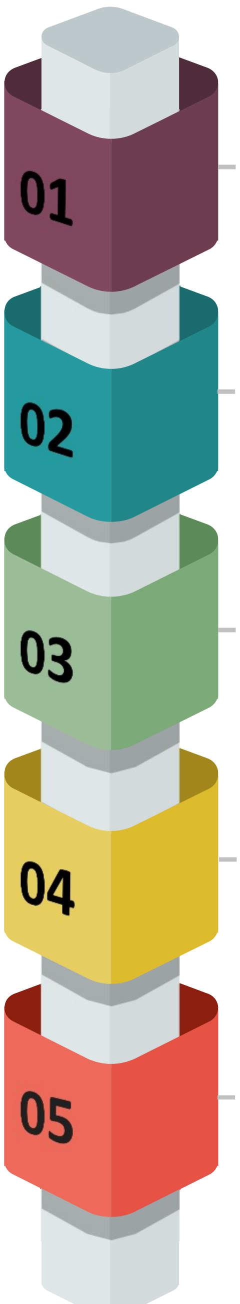
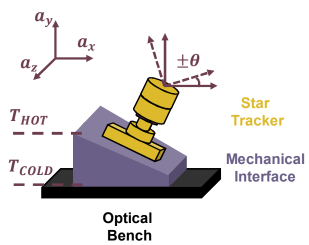
Program: Spontaneous

Project Objective: To develop a new work flow to do multidisciplinary topology optimization on high precision instruments. Specifically, achieve optical pointing requirements while considering thermal-structural coupling.



Formulation

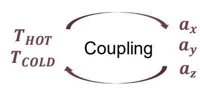
Derive the objectives, the constraints from the relevant load cases defined by the requirements.



Objective
Minimize mass

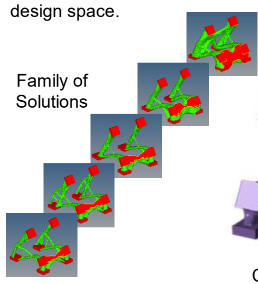
Constraints:
Such that pointing meets requirement

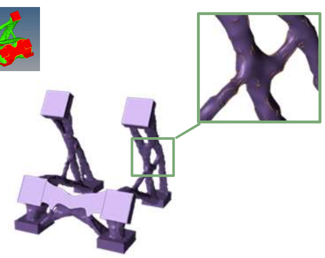
Loading Conditions:
Thermal gradients, Launch loads



Topology Optimization

Apply the Solid Isotropic Material with Penalization (SIMP) method; a mathematical method that optimizes material layout within a given design space.

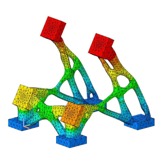




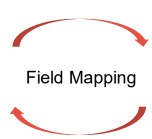
Candidate Solution

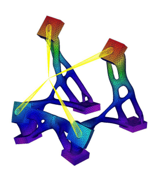
Verification

Verify that the *realized* solution is meeting defined objective and constrains using standard JPL practices



Thermal Analysis



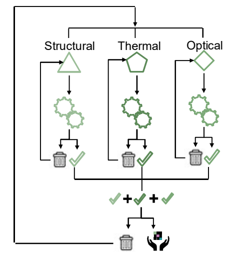


Structural Analysis

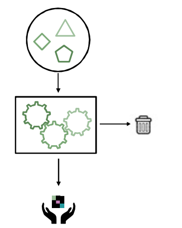
Benefits to NASA and JPL :

This workflow and method, can be applied to other mechanism and instruments

Previous approach- *Each discipline treated separately, and solution is found through iterative process*

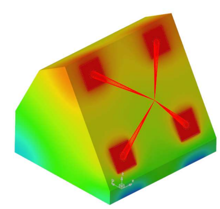


Proposed approach- *Each discipline is linked, and solution is found through topology optimization*

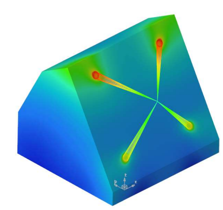


Modelling

Apply the Finite Element Method (FEM). Idealize interfaces, geometry and boundary conditions. Define the design space.



Temperature Field



Displacement Field

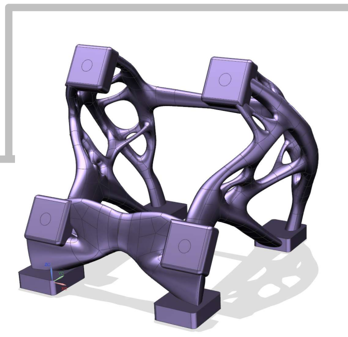
Smoothing

Apply smoothing techniques to optimized solutions to realize manufacturable geometry.

Smoothed Candidate Solution

Smoothed Candidate Solution with Margin on Constraints

FY18/19 Results: As a case study this method was applied to the SWOT Star Tracker; a high precision instrument subjected to thermally induced deformation. Due to the inherent nature of mechanical systems with tight requirements, it was found that solution spaces are limited and sensitive to various inputs throughout the process. Furthermore, there are many technical challenges and limitations with the current state of art tools applied to thermal-structural coupled problems. However, a feasible design (meeting requirements) was produced and manufactured, showing great promise in the studied work flow. This methodology could be applied to other optomechanical instruments subjected to similar design challenges.



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