

Optimization of NTP System Truss to Reduce Radiation Shield Mass

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Abstract. The benefits of nuclear thermal propulsion are numerous and relevant to the current NASA mission goals involving but not limited to the crewed missions to mars and the moon. They do however also present new and unique challenges to the design and logistics of launching/operating spacecraft. One of these challenges, relevant to this discussion, is the significant mass of the shielding which is required to ensure an acceptable radiation environment for the spacecraft and crew. Efforts to reduce shielding mass are difficult to accomplish from material and geometric design points of the shield itself, however by increasing the distance between the nuclear engines and the main body of the spacecraft the required mass of the shielding is lessened considerably. The mass can be reduced significantly per unit length, though any additional mass added by the structure to create this distance serves to offset those savings, thus the design of a lightweight structure is ideal. The challenges of designing the truss are bounded by several limiting factors including; the loading conditions, the capabilities of the launch vehicle, and achieving the ideal truss length when factoring for the overall mass reduced. Determining the overall set of mass values for a truss of varying length is difficult since to maintain an optimally designed truss the geometry of the truss or its members must change. Thus the relation between truss mass and length for these loading scenarios is not linear, and instead has relation determined by the truss design. In order to establish a mass versus length trend for various truss designs to compare with the mass saved from the shield versus length, optimization software was used to find optimal geometric properties that still met the design requirements at established lengths. By solving for optimal designs at various lengths, mass trends could be determined. The initial design findings show a clear benefit to extending the engines as far from the main structure of the spacecraft as the launch vehicle's payload volume would allow when comparing mass savings verse the additional structure.