Vibrations in Space
Application to Satellite Truss Design

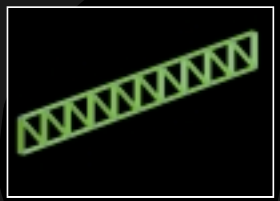
Computational Engineering & Design Centre

Truss in Orbit
NASA STS61B-120-052, 27/11/85

The OPTIONS Design Exploration System has been applied to the design of satellite trusses with enhanced vibration isolation characteristics. The designs are based on a structure assembled by NASA astronauts and were produced using Genetic Algorithm methods and a highly customized vibrational energy flow code.

The NASA 'Assembly Concept for Construction of Erectable Space Structures' (ACCESS) consisted of a tower like device which was built out from the payload bay of the shuttle Atlantis in November 1985 by astronauts Sherwood C. Spring and Jerry L. Ross.

Simplified 2d Model of Truss



Initially, a two-dimensional version of the truss was used for analysis. This consisted of 40 beams and only in-plane vibration transmission was considered.

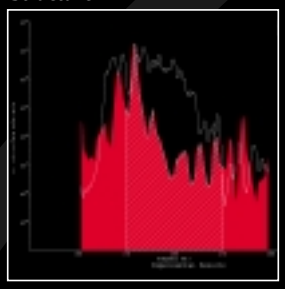
Optimized 2d Model of Truss

Application of the Genetic Algorithm (GA) method within the OPTIONS package, using 4500 design evaluations spread over 18 generations, produced an optimized design with a predicted vibrational energy transmission reduced by 60dB over a 100Hz bandwidth. The GA was run in parallel on a heterogeneous collection of single and multi-processor workstations over a two week period.

Optimized 2d Structure on Test

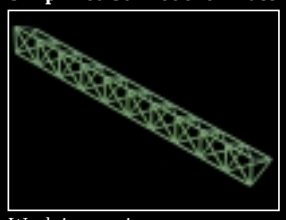
A scale model of the optimal structure was subsequently built and tested alongside a model of the non-optimized design to see if the predicted improvements could be realised in practice.

Frequency Response of 2d Structure



Measurements taken on the non-optimized and GA optimized designs verified that the predicted improvements could be obtained in practice. The correlation between theory and practice owed much to the use of a specifically designed analysis code and careful choice of the precise quantities being controlled by the optimizer.

Simplified 3d Model of Truss



Work is now in progress on optimizing a full 3-dimensional structure, again using a parallel, multi-workstation GA. The structure consists of 120 individual beams and allows for bending, axial and torsional vibrations of the structure. The analysis used has been fully validated against detailed finite element models of the structures constructed with commercial FE codes.

Optimized 3d Model of Truss

The initial designs produced by the optimization process again show significant improvements in vibration isolation but would clearly be more difficult to build and deploy in space than conventional designs. Nonetheless, given that the improvements in vibration control are achieved without weight penalties and only using passive methods, it would seem that this approach has much to commend it.

Full references for papers describing this work and a number of related subjects may be found on the home page of Prof. A.J. Keane (http://www.soton.ac.uk/~ajk/welcome.html).

This article may be found at http://www.soton.ac.uk/~ajk/truss/truss.html

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