

# Simplified Analysis Method for Ultralight Lattice Structures in Additive Manufacturing

## Context

Pratt & Whitney Canada is considering the possibility of producing ultralight lattice structures through 3D printing (also called additive manufacturing), in order to reduce the weight of some pieces of machinery while preserving or improving their characteristics.

These three-dimensional structures are obtained by assembling (in a periodic or non-periodic fashion) a huge number of “unit cells” consisting of nodes and ribs. Several specific cell geometries are proposed in the literature in order to achieve certain mechanical behaviours that are required for particular applications.

Because the cell size is usually of the order of a millimeter, the number of elements required for the analysis of the structure corresponding to the entire piece is enormous and it becomes difficult or impossible to use finite element analysis.

## Project goal and research avenues

In order for a finite element analysis of pieces including lattice structures to be carried out at a reasonable cost and within a reasonable time, it would be highly desirable to define a replacement solid with properties equivalent to those of the original piece (elasticity modulus, shear modulus, Poisson coefficient, in particular).

Here are a few important considerations :

1. The cell geometries proposed in the literature are in general anisotropic. Their orientation and the orientation of the overall structure have a big impact on the characteristics obtained.
2. The cell geometries vary a lot and will change over time, because of the evolution of design and manufacturing technology. The solution we are looking for must be adaptable and take this possible evolution into account.
3. Many applications would benefit from an adaptive meshing, which varies through the piece, in order to allow one to do the following (among other things):
  - a) adjust the properties locally according to the requirements (load restoration, heat transfer, energy absorption, variation in rigidity, etc.) and
  - b) follow a curved or irregular surface (see the figure below).

## Uniform and periodic structure



Source: Laser Institute of America (LIA)

Source :  
<http://www.pwc.com/us/en/technology-forecast/2014/3d-printing/features/3d-printing-innovation.jhtml>

## Non-uniform and non-periodic structure



Source :  
<http://software.materialise.com/conformal-structures>