# A FRAMEWORK FOR MESH QUALITY IMPROVEMENT

**P. Knupp**[a], **L. Freitag-Diachin**[a] and **M. Brewer**[a]

[a]Sandia National Laboratories
Albuquerque, New Mexico 87185
pknupp@sandia.gov, ladiach@sandia.gov, mbrewer@sandia.gov

Mesh quality improvement methods modify existing meshes via node-movement and/or local topology fix-ups to provide applications with meshes that permit robust, accurate, and efficient analyses. A wide range of mesh improvement goals exist including the removal of inverted elements and the creation of smooth meshes with well-shaped, well-sized, and properly oriented elements, often in the context of solution-adaptivity. Such meshes may be structured, unstructured, hybrid,or even non-conformal. An interesting challenge is to unify the wide variety of mesh smoothing and optimization algorithms within a single computational framework in order to maintain both flexibility and efficiency. The MESQUITE mesh quality improvement toolkit, developed under the auspices of the Terascale Simulation Tools and Technology (TSTT) SciDAC center, provides such a framework.

We present a semi-formal statement of the smoothing and optimization framework within MESQUITE. Mesh quality is defined in terms of objective functions that are norms of weighted local geometric quality metrics. By convention, objective functions are *minimized*, possibly subject to constraints. Objective functions are required to be continuous and possess a global minimum. They need not be convex or smooth.

Numerical optimization algorithms are used to produce a sequence of meshes (iterates) which approach a local minimum. The sequence of iterates is halted using various termination criteria to produce the optimized mesh. The optimized mesh is not necessarily a local minimum of the objective function since obtaining that often proves to be too costly. Numerous termination criteria types implemented in MESQUITE are described, together with their underlying assumptions. The criteria include quality, cost, and progress-centric types, as well as some fail-safe criteria. No attempt is made to determine *à priori* which criteria are 'best', rather we let experience be our guide. A series of numerical experiments is performed to compare the effects of various termination critera. By use of compound termination criteria one controls both quality and cost aspects of the minimization. Mesh *culling* algorithms are studied to show their relation to termination criteria. All these topics are examined within the context of large-scale optimization algorithms. Examples of the types of mesh quality improvement problems which can be addressed by MESQUITE are given.

## References

[1] L. Freitag, P. Knupp, T. Leurent, and D. Melander, "MESQUITE Design: Issues in the Development of a Mesh Quality Improvement Toolkit," *Proceedings of the 8th Intl. Conference on Numerical Grid Generation in Computational Field Simulations*, p. 159-168, Honolulu, 2002.