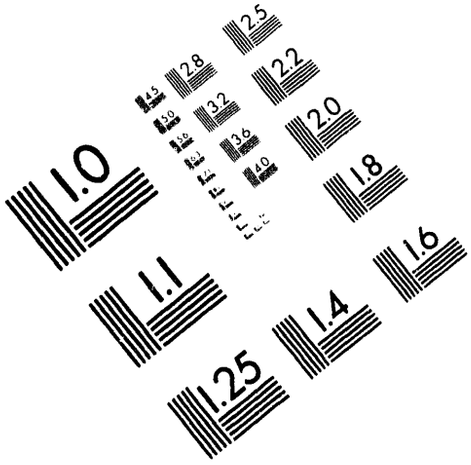

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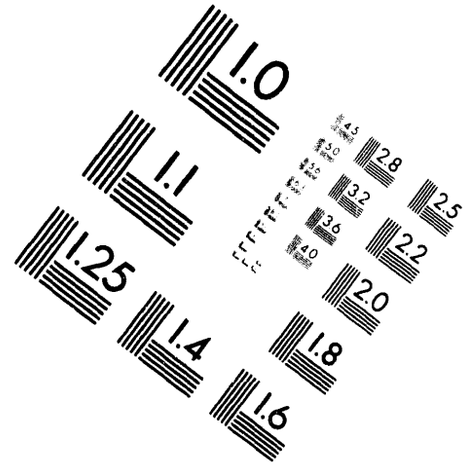

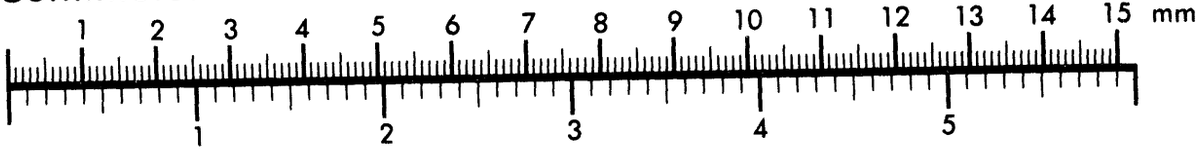

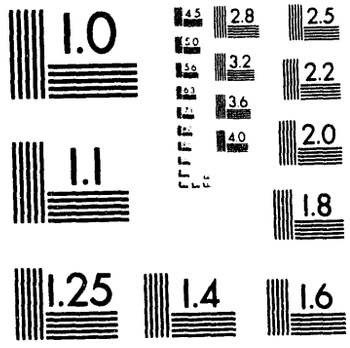

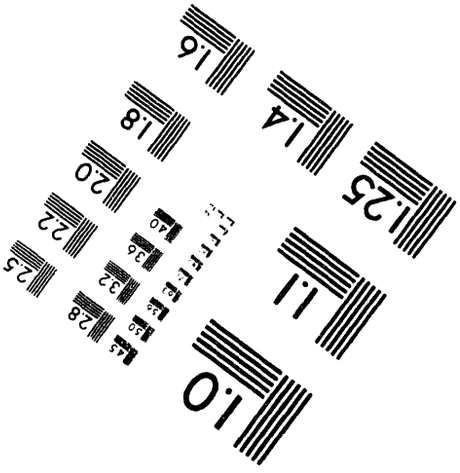

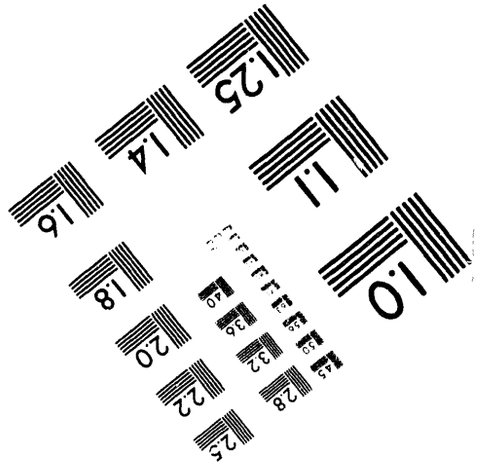

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Conf-941118--6

UCRL- JC-118234
PREPRINT

Meshes: The Next Generation

Mark Christon
John Compton
David Hardin
Mary Zosel

This paper was prepared for submittal to the
Supercomputing '94 conference
Washington, DC
November 14-18, 1994

August 29, 1994

Lawrence Livermore National Laboratory

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Meshes: The Next Generation*

Mark Christon
David Hardin
John Compton
Mary Zosel

Lawrence Livermore National Laboratory
P.O. Box 808
Livermore, CA 94550

Abstract

Building complex meshes for large-scale numerical simulations presents immense difficulties in exploiting high-performance computers. Industry and research leaders will describe the current state of the art for generating meshes for such large scientific problems. This will be followed by a panel and general audience discussion of the algorithmic and architectural issues surrounding the generation of meshes with 10^7 *to* 10^9 *grid points. (Note: The terms "mesh" and "grid" are used interchangeably in the literature.)*

1 Introduction

The increased computational power provided by massively parallel processors will significantly enhance the physical modeling of geometrically complex 3-D problems. However, current meshing software limits both the size and complexity of meshes for thermal, electrodynamic, hydrodynamic, and structural simulation codes. Current meshing methods for complex systems can be so labor intensive that the cost of merely defining a large problem becomes prohibitive. The purpose of this roundtable is to provide a forum for discussing the issues involved in generating meshes for very large problems, namely, those requiring 10^7 to 10^9 grid points.

The audience targeted for this roundtable is mixed. It will be a forum for open discussion by applications developers, but the topic should also appeal to a wider spectrum of computing professionals. This includes managers, vendors, and engineering analysts who want a better understanding of the complexities of generating large 3-D meshes, including the issues introduced by parallel computations.

*Work performed under the auspices of the U. S. Department of Energy by the Lawrence Livermore National Laboratory under contract No. W-7405-ENG-48.

The roundtable is broken into three sessions involving leaders in research on new mesh-generation techniques and users from both government and industry who require large meshes. *User Presentations* is dedicated to the discussion of user requirements for very large meshes. *Current Mesh Generation* presents a spectrum of state-of-the-art meshing techniques applicable to large problems. *Panel and Audience Discussion* is an open forum focusing upon overcoming the difficulties in obtaining meshes with 10^7 to 10^9 grid points.

2 User Requirements

This session will present mesh generation issues as seen through the eyes of the consumer, i.e., analysts and code developers who require large meshes to model geometrically complex physical domains. Speakers will emphasize user requirements for generating very large grids as well as issues related to usability. This session will be approximately 45 minutes long and will be chaired by Niel Madsen, Lawrence Livermore National Laboratory (LLNL).

Speakers will include the following:

- Tim Barth, NASA Ames Research Center: Grid-Generation Requirements for CFD applications
- John Biffle, Sandia National Laboratories: Requirements of the Auto Industry
- Vijaya Shankar, Rockwell International: Grid Requirements for E&M Applications
- Joe Thompson, Mississippi State University: Gridding Requirements as Defined by End Users in the National Grid Project

3 Current Mesh Generation

Algorithms for mesh generation range from simple techniques (such as algebraic methods for multiblock generators) to more complex methods (such as paving,

recursive octree methods and Delaunay triangulation). Current techniques for geometry decomposition and meshing will be discussed by leading experts. This session will be approximately 75 minutes long and will be chaired by Mark Christon, LLNL.

Presentations will be given by the following researchers:

- Ted Blacker, Sandia National Laboratories: Paving, Plastering and Whisker Weaving for Quad and Hex Meshing
- Peter Eiseman, Columbia University: Multiblock Grid Generation with Automatic Zoning
- Mark Shephard, Rensselaer Polytechnic Institute: Unstructured Grid Generation and Control for Large Scale Adaptive Computations on Parallel Computers
- Thomas Tam, FEGS: Auto Quad and Hex Meshing by Medial Object Subdivision
- Nigel Weatherill, Swansea: Unstructured Grids by Point-Insertion Strategies

4 Panel and Audience Discussion

This session is intended to provoke a lively discussion involving both the panel members and the audience. The focal point hinges on the question: What are the challenges in building meshes with 10^7 to 10^9 grid points? This session will be approximately one hour long and will be chaired by John DeFord, MacNeal-Schwendler Corporation (formerly of LLNL). Panel members will include: Tim Barth, Ted Blacker, Cliff Shang (LLNL), Joe Thompson, Nigel Weatherill, and Mark Shephard.

5 Summary

There are three primary goals for this roundtable. The first goal is to expose a wide audience from the high-performance computing community to the importance of mesh generation. The second goal is to focus attention on the requirements for large simulations and the special difficulties in setting them up. The third goal is to provide a forum where applications developers can meet with mesh generation researchers specifically to discuss very large problems.

6 Participant Affiliations

Tim Barth, NASA Ames Research Center, is involved in computational fluid dynamics (CFD) and unstructured mesh generation.

Johnny H. Biffle is Program Manager of the Engineering Technology Programs at Sandia National Laboratories and is developing programs in computational mechanics research and technology transfer.

Ted Blacker is a Senior Member of the Technical Staff at Sandia National Laboratories and project manager of CUBIT, an advanced meshing algorithm research program.

Mark Christon is a member of the Methods Development Group at LLNL and is involved in research in computational fluid dynamics and fluid-structure interaction.

John DeFord is a senior product support engineer in the Electromagnetic Application Department at MacNeal-Schwendler Corporation.

Peter Eiseman is president of Program Development Corporation and Adjunct Professor of Applied Physics at Columbia University.

Niel Madsen leads the Fields, Materials, and Plasma Modeling Group in the Electronics Engineering Department and is the author of the DSI3D code at LLNL.

Cliff Shang is the Computational Electronics and Electromagnetics Thrust Area Leader in the Engineering Directorate at LLNL.

Vijaya Shankar is Director of Computational Sciences, Rockwell Science Center, and is responsible for developing time-domain electromagnetics solvers.

Mark Shephard holds the Johnson Chair of Engineering and is Director of the Scientific Computation Research Center at Rensselaer Polytechnic Institute.

Thomas Tam is a Senior Project Manager at FEGS, Ltd., Cambridge, UK, and leads a research team developing medial-object decomposition methods.

Joe Thompson is Director of the NSF Engineering Research Center for Computational Field Simulation and Distinguished Professor of Aerospace Engineering at Mississippi State University.

Nigel Weatherill is Professor of Civil Engineering at the University College of Swansea, UK, and Adjunct Professor at the NSF Engineering Research Center, Mississippi State University.

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