Altitude Compensating Nozzle Concepts Evaluations

A
Report Submitted to

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By

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Abstract:

This report contains the summary of work accomplished during summer of 2000 by Mr. Chad Hammons, undergraduate senior student, Mississippi State University/ERC in support of NASA/MSFC mission pertinent to Altitude compensating nozzle concepts evaluations. In particular, the development of automatic grid generator applicable in conducting sensitivity analysis involving Aerospike engine is described.

Background:

Current grid generation techniques used to construct grids for the X-33 linear aerospike engine require that the grid be rebuilt from scratch every time a new parameter or new set of data is received. In expectation of receiving several new configurations, the Applied Fluid Dynamics Analysis Group (TD64) at NASA Marshall Space Flight Center requested an automated process to decrease time spent constructing the grids.

Dr. Soni of Mississippi State University's Engineering Research Center (ERC) proposed to create an automatic grid generator for the specific geometry of the linear aerospike engine. The work is accomplished by an undergraduate senior student, Chad Hammons during summer 2000. The development of the automatic grid generator tailored for Aerospike engine was completed.

Three objectives were set by NASA personnel:

1. To apply a state of the art grid generator in support of the development of altitude compensating nozzles.
2. To use a post processor software package to visualize the grid and flow field solution.
3. To fully document the processes used in tasks #1 and #2.

A copy of the original request is listed in the appendix A.1.

Analysis:

Custom FORTRAN code was used to build the automatic grid generator (Auto2d). The code also used several grid subroutines from Genie2D, a two-dimensional grid generator written by Dr. Soni. Constant interaction between the student and NASA personnel was maintained in order to be sure the program included all of the options necessary for a quality grid. A full listing of the code and a sample input file are included in the appendix.

The code minimized inputs while maximizing the flexibility of the code to generate a variety of grids. The code required five inputs: four sets of points that define key contours in the grid and one input file for spacing and other options. As often as possible the code uses either already defined spacings or ratios of already defined spacings. The code also minimizes the number of curves that have to be read in by using a custom subroutine to mirror the thruster contours using a tilt angle and area ratio given in the input file.

Several options were included to improve the quality of the grid. Bezier curves were used to define zonal boundaries at sharp angle intersections to decrease the skew of the individual cells around the intersection. The slope of the bezier curve from the intersection is a user-defined parameter that is included in the input file. Other included options can be seen either in the sample input file, or in the full code listing. The listing of the code with input file for the candidate configuration is provided to NASA technical personnel.

Conclusions:

Due to the time it took to complete the automatic grid generator, no solutions could be run to obtain a flow field solution. Task two could not be completed because of this reason. However, visualization packages called FieldView and FAST were used to verify grid quality and certain desired grid characteristics. Rather than completing a partially functional grid generator and then moving to task two, it was decided that creating a fully functional code was more desirable. The code also was fully documented both in the code and in a binder that is on file at NASA Marshall.

The code has potential to be turned into a three-dimensional grid generator later. The code also can be modified to include grid quality subroutines such as grid adaptation, grid measuring, and elliptic solvers. Overall, NASA was left with a well-documented, quality code that should serve its purpose with little or no additional modification.

Appendix A.1:

Altitude Compensating Nozzle Concepts Evaluation

The Applied Fluid Dynamics Analysis Group (TD64) is tasked with the development of several altitude compensating nozzle (ACN) concepts. In order to accomplish this task, TD64 requires support in the area of grid generation and solution post-processing. The following tasks define the work to be accomplished in support of TD64's ACN task.

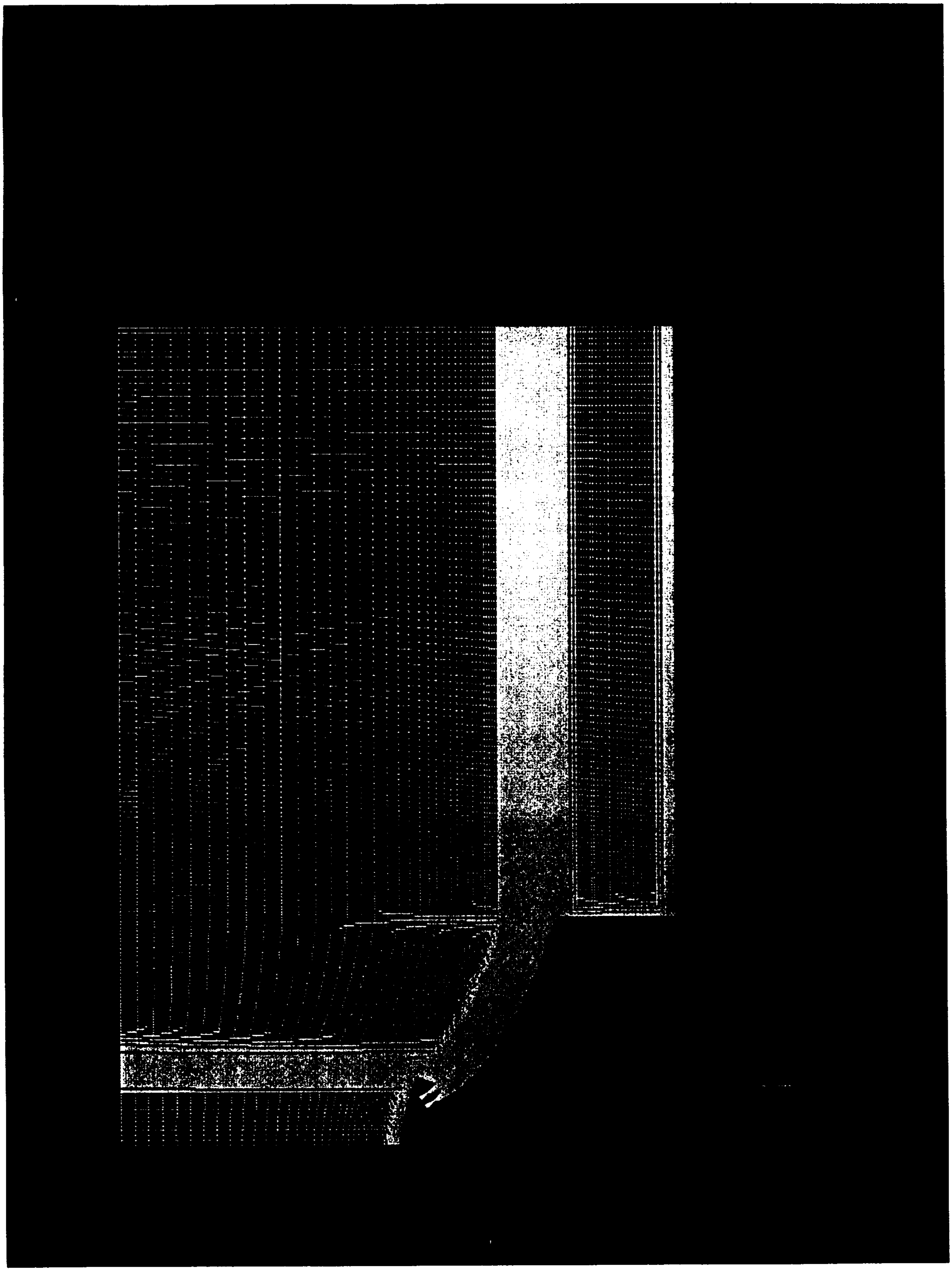
1) Apply a state of the art grid generator (Genie ++ or Gridgen) in support of the development of two nozzle concepts. Due to the large number of geometries to be accessed, it is anticipated that this task will require partial or complete automation of the grid generation process. Furthermore, it is anticipated that the majority of the effort will involve two-dimensional grids.

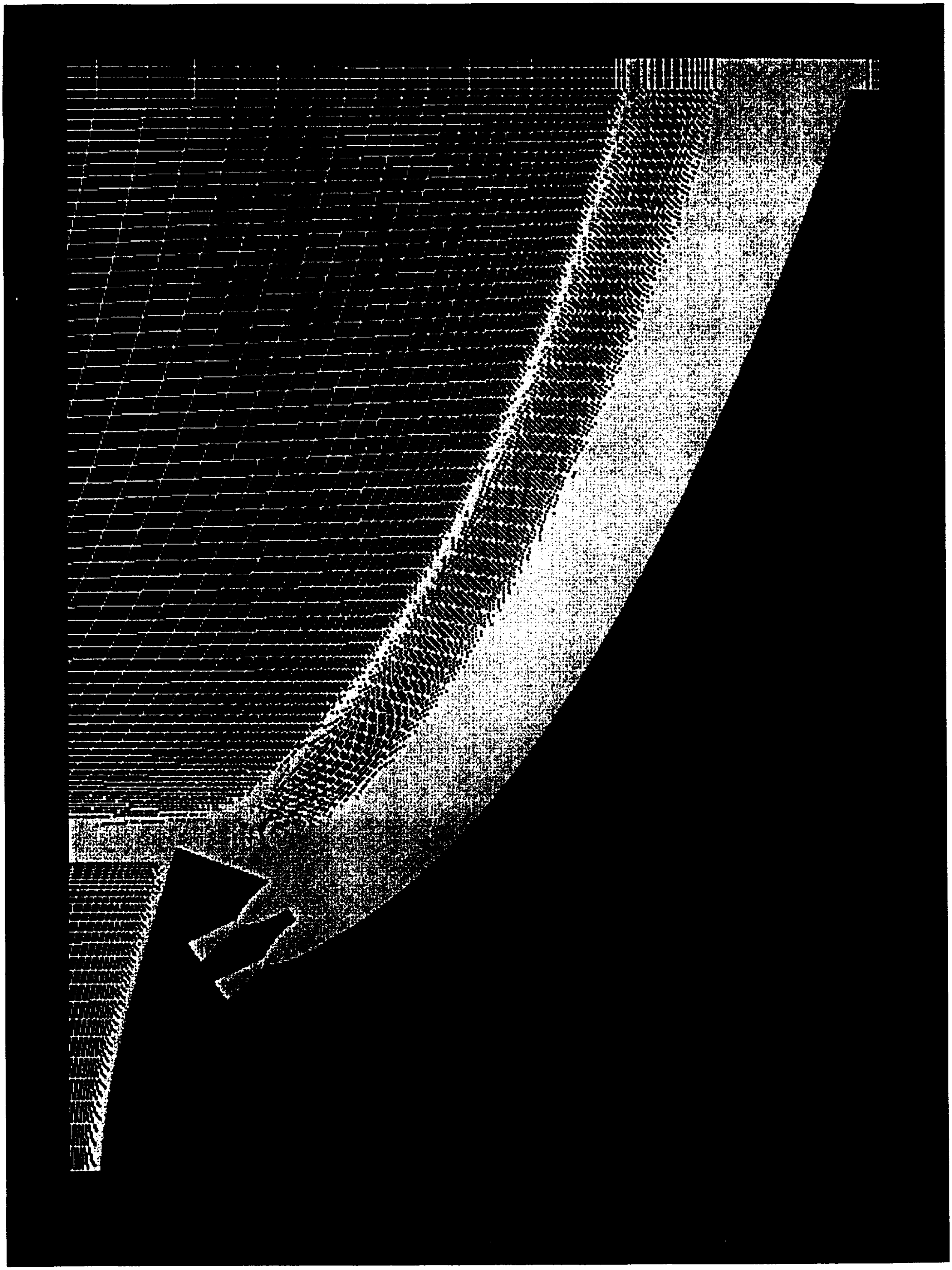
2) Apply a state of the art post-processing tool (Fieldview, Ensight, or FAST) to visualize and to extract engineering data from the flow field solutions. It is anticipated that for the engineering data extraction, a custom FORTRAN code will need to be written or existing codes will have to be modified. Furthermore, due to the large number of cases to be analyzed, it is anticipated that some degree of automation will be required.

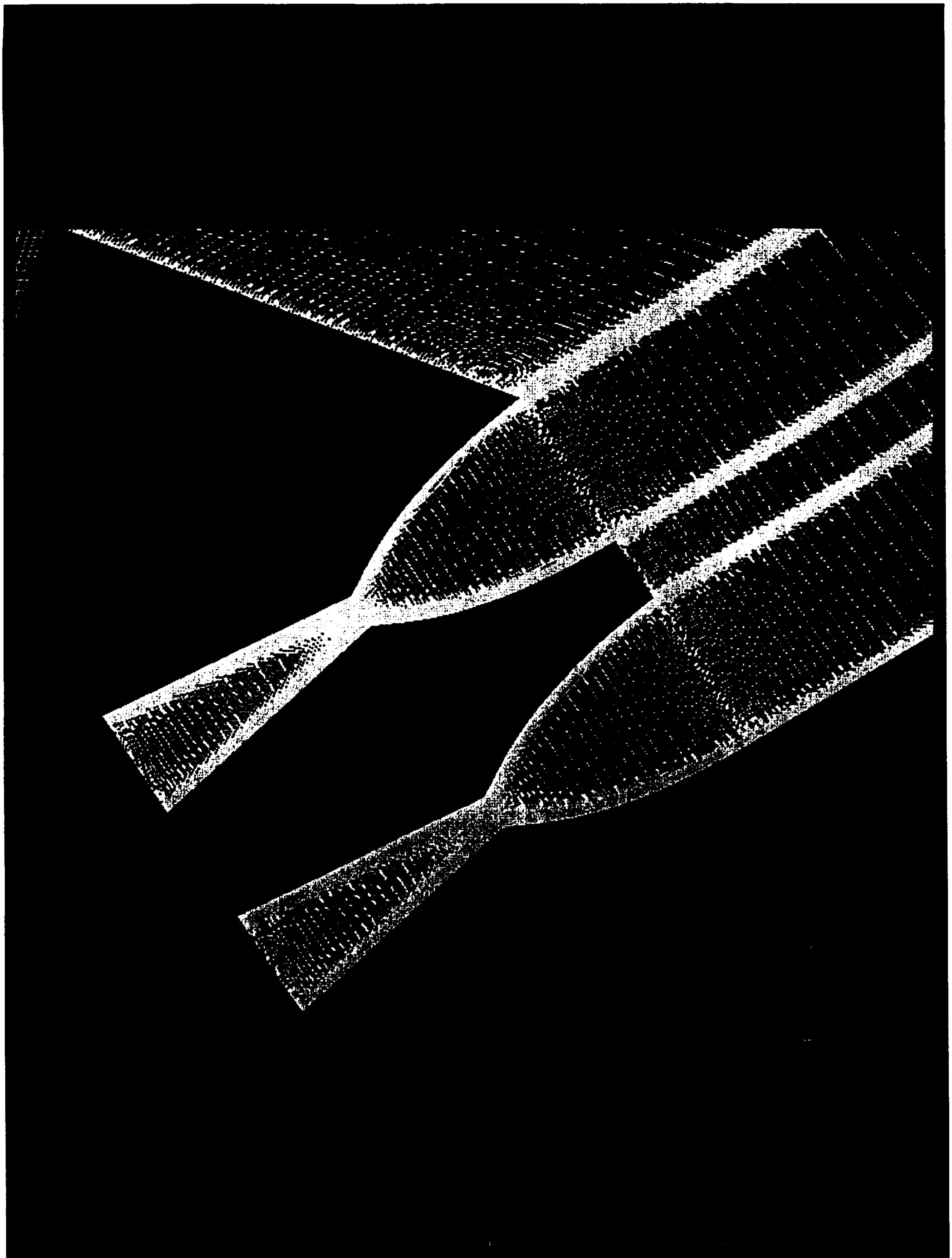
3) Document the procedures developed and implemented under tasks #1 and #2. Summarize the lessons learned with regards to the automation of the pre- and post-processing. Summarize lessons learned with regards to the flow physics observed during the visualization of the solutions.

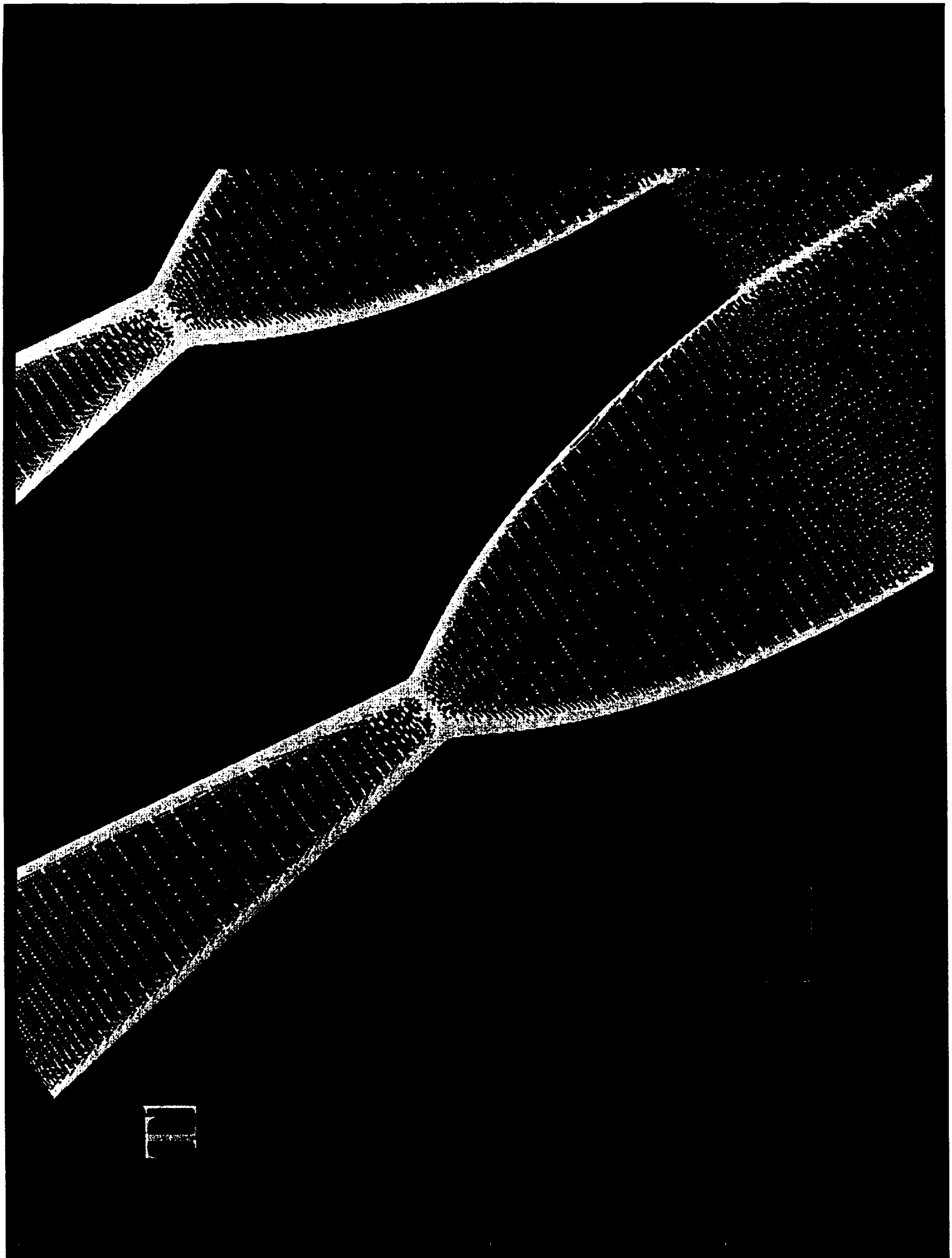
To accomplish these tasks close cooperation and coordination will be required with TD64 personnel.

It is required that this activity begin on or near May 29, 2000 and be completed by August 4, 2000.









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