TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): __FHWA____

INSTRUCTIONS:
Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project #		**Transportation Pooled Fund Program - Report Period:**
TPF-5(279)		☐Quarter 1 (January 1 – March 31) 2015 ☑Quarter 2 (April 1 – June 30) 2015 ☐Quarter 3 (July 1 – September 30) 2015 ☐Quarter 4 (October 1 – December 31) 2015
Project Title: *High Performance Computational Fluid Dynamics (CFD) Modeling Services for Highway Hydraulics*		
Name of Project Manager(s): *Kornel Kerenyi*	**Phone Number:** *(202) 493-3142*	**E-Mail** *kornel.kerenyi@fhwa.dot.gov*
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**

Project schedule status:

☑ On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date

Project Description:

The Federal Highway Administration established an Inter-Agency Agreement (IAA) with the Department of Energy's (DOE) Argonne National Laboratory (ANL) Transportation Analysis Research Computing Center (TRACC) to get access and support for High Performance Computational Fluid Dynamics (CFD) modeling for highway hydraulics research conducted at the Turner-Fairbank Highway Research Center (TFHRC) Hydraulics Laboratory. TRACC was established in October 2006 to serve as a high-performance computing center for use by U.S. Department of Transportation (USDOT) research teams, including those from Argonne and their university partners. The objective of this cooperative project is to:

- Provide research and analysis for a variety of highway hydraulics projects managed or coordinated by State DOTs
- Provide and maintain a high performance Computational Fluid Dynamics (CFD) computing environment for application to highway hydraulics infrastructure and related projects
- Support and seek to broaden the use of CFD among State Department of Transportation employees.

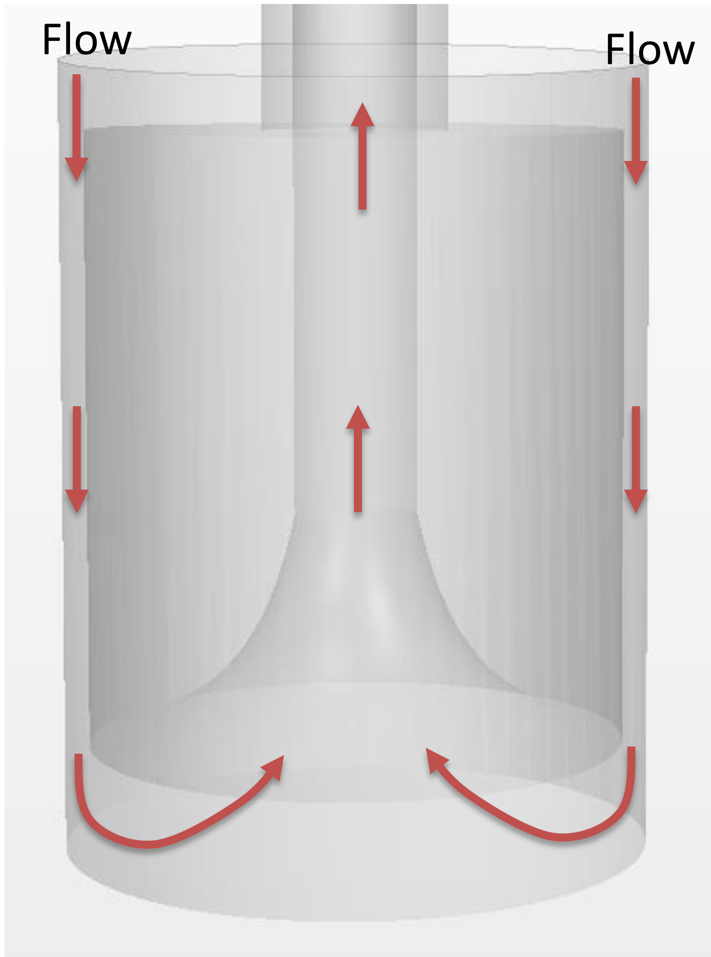
The work includes:

- Computational Mechanics Research on a Variety of Projects: The TRACC scientific staff in the computational mechanics focus area will perform research, analysis, and parametric computations as required for projects managed or coordinated by State DOTs.
- Computational Mechanics Research Support: The TRACC support team consisting of highly qualified engineers in the CFD focus areas will provide guidance to users of CFD software on an as needed or periodic basis determined by the State DOTs.
- Computing Support: The TRACC team will use the TRACC clusters for work done on projects; The TRACC system administrator will maintain the clusters and work closely with the Argonne system administrator's community; The TRACC system administrator will also install the latest versions of the STAR-CCM+ CFD software and other software that may be required for accomplishing projects.

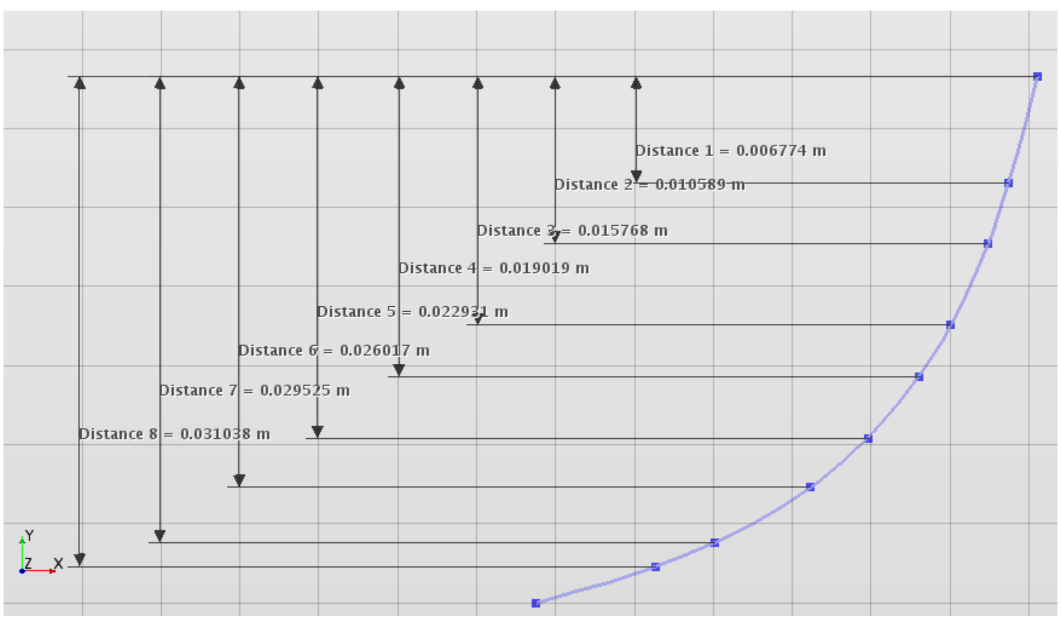
Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

- Optimized Design of In-situ Scour Testing Device (ISTD) Erosion Head
  - An in-situ scour testing device was developed by the Hydraulics Laboratory in Turner-Fairbank Highway Research Center (TFHRC) for use as a foundation design aid for the highway and bridge engineering community. One of the challenges is to achieve a flat surface at the bottom of the flow, i.e., the interface between the flow and bed material. The uniformity of this interface is critical for the accuracy of shear stress measurement because: 1) a horizontal flat surface can better represent a uniform distribution of shear stress applied to the soil, 2) more accurate measurement of the erosion rate can be obtained for the even surface, and 3) ISTD may have a lower risk of being blocked by sediment suction.
  - CFD simulation was conducted to optimize the shape of ISTD erosion head to achieve a uniform bed shear stress distribution. A spline of eight parameters was selected as the function to represent the shape of erosion head. The objective of optimization is to minimize the standard deviation of the shear stress on the bottom of flow as well as maximize the uniformity of the shear stress. The uniformity is computed as:

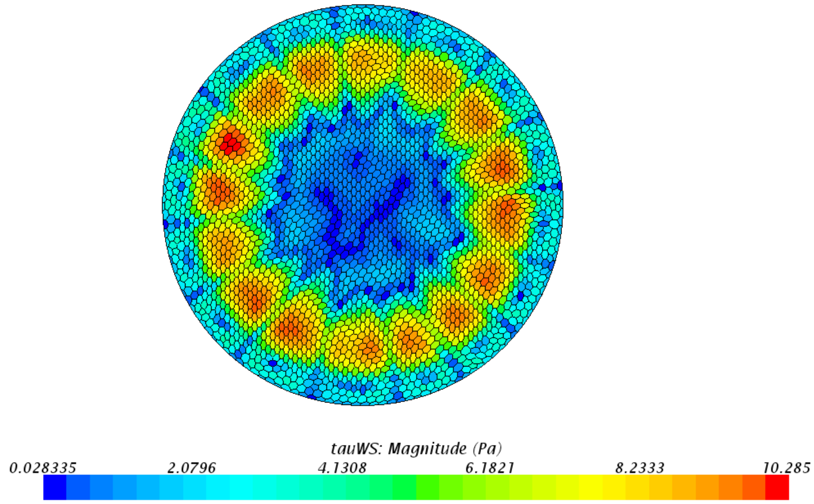
$$\text{Uniformity index of } \phi = 1 - \frac{\sum_f |\phi_f - \bar{\phi}| A_f}{2|\bar{\phi}| \sum_f A_f}$$



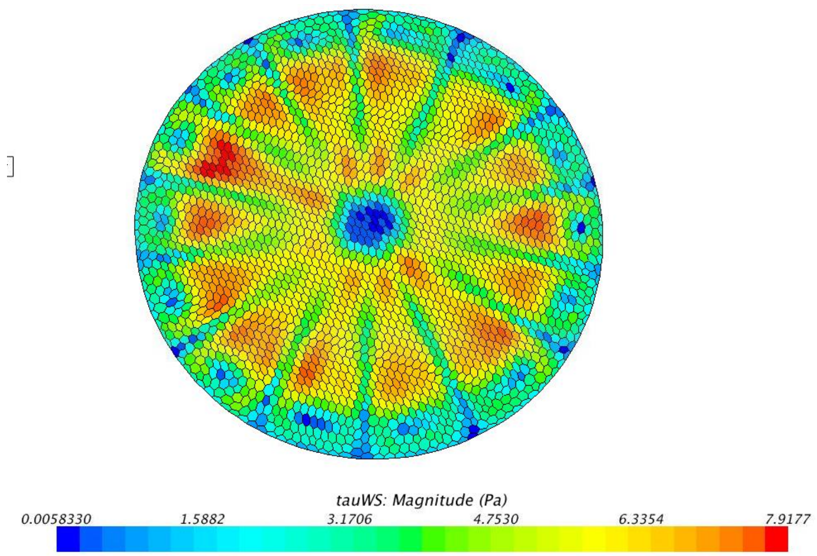
Geometry of the ISTD erosion head



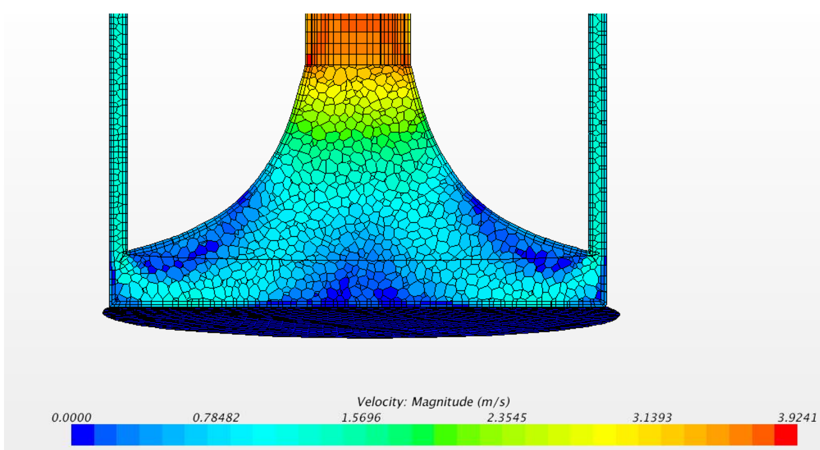
The spline function with eight parameters selected for the erosion head



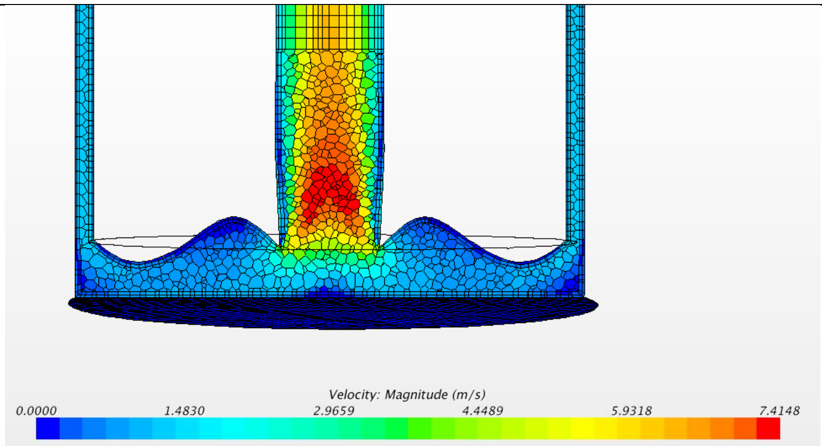
Bed shear stress distribution of initial design, uniformity = 0.695



Bed shear stress distribution of optimized design, uniformity = 0.845



Velocity distribution of initial design



Velocity distribution of optimized design

Anticipated work next quarter:

- Potentially a further optimization on the ISTD erosion head is needed for other criteria such as maximizing the flow velocity and increasing the erosion force applied to the bed.

Significant Results:

- The shape of the erosion head for ISTD was optimized based on the results of CFD simulations to maximize the uniformity of the shear stress.

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

None to report.

Potential Implementation: