MathWorks Math Modeling (M3) Challenge 2020

# KEEP ON TRUCKING: U.S. BIG RIGS TURNOVER FROM DIESEL TO ELECTRIC

Containerized cargo shipments account for a large segment of the United States transport infrastructure; an estimated 1.7 million semi-trucks (also known as tractor trailers and big rigs) carry nearly everything we buy or build. Diesel fuel powers these semis as they travel an estimated 150 billion miles annually, accounting for more than 12% of the fuel purchased in the U.S. The fuel efficiency of diesel semis is, on average, an abysmal 5.98 to 7.3 miles per gallon, which makes the trucking industry ripe for change according to North American Council for Freight Efficiency (NACFE). While more infrastructure is needed to ensure the success of this new approach to trucking, electric semis are becoming an attractive option for companies to consider now, as their current fleets of diesel trucks age and become nonoperational. The 2020 M3 Challenge problem asked teams to create a model to predict what percentage of semi-trucks will be electric in the next few years and decades, determine the number and locations of charging stations along major U.S. trucking routes that are needed for an all-electric trucking industry, and to prioritize which routes should be developed with electric charging infrastructure first. Over a long weekend in early March, 760 teams teams composed of nearly 3,500 students worked on solution papers of up to 20 pages, competing for $100,500+ in scholarships in [MathWorks Math Modeling (M3) Challenge](http://link.email.dynect.net/link.php?DynEngagement=true&H=w8Bl7ZSLqC%2BFFEF9P0XN9HJB14ltnTgt2r4zKtmGsiA5bfE55aykH9W1NTDWgegmczCCzq%2FL7aDXelbX5E7e%2BFCJNd23aJ71OWFuF%2FAjwSSTL6Bu%2FXPRyg%3D%3D&G=0&R=https%3A%2F%2Fm3challenge.siam.org%2F&I=20170228214620.000004d4fbb3%40mail6-51-ussnn1&X=MHwxMDQ2NzU4OjU4YjVlZjdjYTNiMTM5ODllMDQ5YmU1NDs%3D&S=eVfaszSNnJOw19K6lP2o54lafFXbTpiDOoR3akN5HOU" \t "_blank), a program of SIAM.1

M3 Challenge is a unique, internet-based math competition that provides a transformative, real-world experience for high school students, giving them the opportunity to demonstrate how the math they learn in class can be used to make predictions and provide insight about important topics in today’s world and ultimately solve real problems. Now entering its 16th year, M3 Challenge has awarded more than $1.5 million in scholarships since its launch in 2006.

Organized by Society for Industrial and Applied Mathematics (SIAM) and sponsored by leading software developer MathWorks, M3 Challenge seeks to make math relatable to everyday life and to inspire students to study and pursue careers in applied math, computational and data sciences, and technical computing. Free and open to all high school juniors and seniors in the United States, M3 Challenge has drawn the participation of more than 48,000 students (one third female), 4,000+ high schools, 5,000+ teachers, and 400+ Ph.D.-level judges. It has been endorsed by the National Association of Secondary School Principals (NASSP) since 2010. In 2021 in a first international foray, England and Wales’ sixth form students will also be invited and eligible to form teams and submit papers.

Working in teams of three to five members under a 14-hour time constraint, participants use the mathematical modeling process, as well as other skills and experiences, to understand and define a particular problem, gather data and information, document their assumptions, and devise a math model to provide insight for decisions about the issue before submitting their solution via computer upload. Teams may opt to use technical computing to advance a model or better reveal its implications, and extra-credit awards exist for outstanding work in that area.

After four rounds of rigorous judging by 149 professional applied mathematicians over the eight weeks immediately following Challenge weekend, six finalist teams and three technical computing awardees were selected to present their solutions to a panel of mathematical experts in New York City on April 27. Unfortunately, COVID-19 derailed the in-person event, and instead those nine top teams were invited to submit [video presentations](https://www.youtube.com/playlist?list=PLf_ipOSbWC86dNdRO-JUsrKjYO8wUyztH) of their work, which are viewable on YouTube. Outstanding communication awards in amounts of $500 or $1000 were added to team prizes of video submitters. Thirty-seven teams were recognized with scholarship prizes starting at $1,000; the Champion team received $20,000.

The following is the Champion team’s paper from the MathWorks Math Modeling Challenge 2020 **with some reviewer suggestions incorporated**.

Complete information about MathWorks Math Modeling Challenge, including an archive with problems and solutions from each Challenge year, is available at <http://m3challenge.siam.org>.

Michelle Montgomery

Program Director

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A program of Society for Industrial and Applied Mathematics

1. Much of the text of this paragraph comes from the 2020 M3 Challenge [problem statement](https://m3challenge.siam.org/archives/2020/problem).