MathWorks Math Modeling Challenge 2020

A CONTEST FOR HIGH SCHOOL STUDENTS
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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) (see link on side 2).

Tesla is planning to roll out a line of electric semis in 2020 and PepsiCo, Walmart, and UPS have committed to buying a few hundred. 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.

1. **Shape up or ship out**—Assume that all necessary electric semi infrastructure is already in place so that companies could seamlessly transition to an all-electric fleet today. Create a mathematical model to predict what percentage of semis will be electric 5, 10, and 20 years from 2020. You may consider the current fleet of operational semi-trucks, annual new truck production rates and their estimated lifetime, the cost difference between diesel and electric semi-trucks (both purchase and operational costs), and/or any other factors you deem important.

2. **In it for the long haul**—Sustainable large-scale electric trucking will require the development and installation of charging infrastructure along all major trucking routes. Create a mathematical model that determines how many stations are needed along a given route and how many chargers are sufficient at each station to ensure the current level of single-driver, long haul traffic would be supported if all trucks were electric. Demonstrate how your model works by testing it on the following corridors.
    - San Antonio, TX, to/from New Orleans, LA
    - Minneapolis, MN, to/from Chicago, IL
    - Boston, MA, to/from Harrisburg, PA
    - Jacksonville, FL, to/from Washington, DC
    - Los Angeles, CA, to/from San Francisco, CA

3. **I like to move it, move it**—The transition to electric trucking can be an exciting, albeit expensive, development for the communities surrounding the trucking corridors. Some communities are excited at the prospect of economic development and increased revenue that charging stations might bring. Other communities are more inspired by the projected improvement in environmental factors such as air quality. Develop a mathematical model to rank the trucking corridors to determine which should be targeted for development first. You may consider your solution to #2, community motivation for transition, cost, anticipated usage, route length, or other factors. Demonstrate how your model works by ranking the same five corridors mentioned in #2.

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Your submission should include a one-page executive summary with your findings, followed by your solution paper—for a maximum of 20 pages. If you choose to write code as part of your work to be eligible for the technical computing prize, please include it as an appendix and check the box on the upload page. Cite your sources, including those in the provided data files if you use them. Any code appendix or reference page(s) will not count toward your 20-page limit.

Data Statement:

Various organizations and agencies collect data on a regular basis. Some data has been compiled for M3 Challenge use and is provided here: https://m3challenge.siam.org/node/478. You are not required to use this data. You may choose to use none, some, or all of this data and/or any additional data sources you may identify while working on this problem. Be sure to cite all resources used.

Links for getting started:

https://m3challenge.siam.org/node/478 — This landing page contains direct links to a few data sets compiled for teams to consider, as well as an information sheet with terminology, definitions, and links to the data. It is highly recommended that teams review this document!

https://nacfe.org/future-technology/electric-trucks/ — **Electric Trucks–Where They Make Sense** (North American Council for Freight Efficiency). The guidance report mentioned at this site is extensive; we do not expect all information in the guidance report to be useful or for teams to review the report in its entirety. Some salient points in the report have been included in the information sheet mentioned above.

https://www.ups.com/us/es/services/knowledge-center/article.page?kid=ac91f520 — **Inside UPS's Vehicle Strategy** (UPS)

MATLAB Users:

If you are trying to use Excel or any other spreadsheet data in MATLAB, you can import the data by double-clicking the files in MATLAB's "Current Folder" browser or use the Import Data Button **(**https://www.mathworks.com/help/matlab/spreadsheets.html?ue**)** at the top of the Toolstrip.

Watch this quick MATLAB video tutorial **(**https://www.youtube.com/watch?v=0hArv-UBKQQ&list=PLn8PRpmsu08oBSjfGe8WIMN-2_rwWFSgr&index=14**)** about importing spreadsheet data.

See how the MATLAB Import Tool (https://blogs.mathworks.com/cleve/2018/10/05/mathworks-math-modeling-challenge/#just-eat-it) was used in a previous year's problem to import and analyze data.

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SIAM gratefully acknowledges the enthusiasm and help from the North American Council for Freight Efficiency (NACFE) in identifying some of the big questions they face, and providing access to data.