MathWorks Math Modeling Challenge 2020

A CONTEST FOR HIGH SCHOOL STUDENTS
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Keep on Trucking Information Sheet

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DATA STATEMENT:

Various organizations and agencies collect data on a regular basis. A small amount of data has been compiled and provided here; links to data are embedded in this document and summarized toward the end. You are not required to use this data; that is, 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.

BASIC TRUCKING INFO/TERMINOLOGY:

Trucks are classified based on weight. Semis are typically class 8, along with vehicles like tour buses, fire trucks, and cement mixers. A visual showing all types of vehicles by weight class can be found here: https://afdc.energy.gov/data/10381

There are three types of semi-trucks in operation:

1. Short Haul (SH)
   - operate within a 50-mile radius of their home terminal and return each day
   - multiple trips per day, averaging about 150 miles per day, but up to 400 miles per day
   - make up 5% of all semis

2. Regional Haul (RH)
   - operate within 300 miles of their home terminal and return each day or every other day
   - this is a growing segment of the population as items such as e-commerce and other technological advances as global positioning, load matching, etc. enable more dedicated, orchestrated freight movement[1]
   - make up 45% of all semis

3. Long Haul (LH)
   - operate about 500 miles per day on disparate routes, with the driver sleeping at truck stops along the routes and returning to the home terminal about every week or two weeks
   - also known as over-the-road trucking
   - make up 50% of all semis

Driver hours-of-service regulations[2]:

- For safety purposes, drivers may work no more than 60 hours on-duty over seven consecutive days or 70 hours over eight days.

- Drivers may be on duty for up to 14 hours following 10 hours off duty, but they are limited to 11 hours of driving time.

CONTINUED

INFO ON DIESEL TRUCKS:

Today there are approximately 1.7 million diesel semi-trucks on the road.

Every year new diesel trucks are produced which replace older trucks. Data on truck production rates and usage are available here under the production tab of the semi_production_and_use spreadsheet.

- Diesel truck life is about 12 years.

- LH trucks average approximately 110 thousand miles/year in the first 5 years, and then their mileage typically declines to 80 thousand miles/year in remaining years.

- Most LH fleets sell their trucks after approximately 5 years and replace them with new trucks, selling the trucks to smaller fleets, sometimes for short or regional haul.

- As trucks age it may be best to keep them closer to "home."

Fuel Efficiency of diesel trucks:

- Average fuel efficiency of all diesel trucks in North America is 5.98 MPG (with a group of fleets participating in the NACFE Annual Fleet Fuel Study significantly higher at 7.3 MPG).[3]

- Diesel trucks continue to improve their MPG based on end user fleet demands and regulations in place in the U.S. and Canada.

INFO ON ELECTRIC TRUCKS:

Range and efficiency:

- Many claims are being made on the expected range of the newly emerging heavy-duty tractors. They range from 600 miles on a single charge (Tesla) to around 200 miles (Daimler electric e-Cascadias).

- Efficiency of electric trucks is generally believed to be approximately 2 kWh/mile for flat terrain at moderate temperatures around 68F.

Battery info:

- Charging time depends on battery pack size and state of charge. As an example, a 400 mile electric truck at 2 kWh/mi needs 800 kWh of battery capacity before considering ambient conditions, terrain, and other factors. A simple view of charging power required is then based on time. Real chargers have losses and other factors to also consider. Some basic data about batteries is provided here under the basic_charging_info tab of the battery_data spreadsheet.

- Battery life is better when the state of charge is kept between 20% and 80% of capacity.

- Battery life is really battery capacity, which decreases every charge cycle. For example, a battery rated at 10 years life begins life with 100% capacity, but after 10 years can only be charged to 80% of its original capacity.

- Examples of battery charging scenarios are shown here under the charging_scenarios tab of the battery_data spreadsheet.

- Faster charging with higher power shortens battery life faster.

- Battery packs cost $180-$200/kWh with a goal of $100/kWh in the future.

- Capabilities and costs of today's battery chargers are shown here under the charging_capability tab of the battery_data spreadsheet.

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TRUCKING CORRIDOR INFO:

For each of the corridors, a sample of data on traffic counts has been provided <u>here</u> in the corridor_data spreadsheet.

General information on the data appears on the Notes tab, and each corridor has its own tab.

SUMMARY OF DATA PROVIDED:

All data is located at this page: **https://m3challenge.siam.org/node/478**

Semi_production_and_use: This spreadsheet has two tabs.
- *Production*: this tab contains the number of trucks produced each year from 1999 to 2019.
- *Usage_info*: this tab contains information about how SH, RH, and LH trucks are used, on average.

Corridor_data: This spreadsheet has five tabs.
- *Notes*: this tab defines the data types you will see on each subsequent tab (e.g., AADTT). There are also notes about how the data was collected and how teams might consider using the data provided.
- *Other tabs*: this tab provides information on traffic along each corridor.

Battery_data: This spreadsheet has three tabs.
- *Basic_charging_info*: this tab contains some basic charging guidelines.
- *Charging_scenarios*: this tab contains information that has been provided by electric truck production companies about how their batteries might be charged.
- *Charging_capability*: this tab provides information about different types of electric vehicle chargers, including costs.

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** at the top of the Toolstrip. Watch this quick MATLAB **video tutorial** about importing spreadsheet data. See how the **MATLAB Import Tool** was used in a previous year's problem to import and analyze data.

CONTINUED

10 ARGUMENTS
FOR AND AGAINST ELECTRIC TRUCKS

Argument **FOR** Electric Trucks	VS.	Argument **AGAINST** Electric Trucks
1 Commercial battery electric vehicle (CBEV) weight is not an issue	**WEIGHT**	**1** Vehicle tare weight is too high to support my freight needs
2 CBEV technology is proven and here now		**2** Technology is not ready
3 Maintenance will be less costly	**TECHNOLOGY**	**3** Maintenance may not be less costly
4 CBEVs will last beyond 10 years		**4** Vehicle life is too short
5 CBEVs will be competitively priced		**5** Vehicle purchase price is too high for a positive ROI
6 CBEVs will be less expensive to operate	**COST**	**6** Vehicle operating costs are too great for positive ROI
7 CBEVs will command a premium at resale		**7** Vehicle residual value is questionable
8 Trust the market to provide CBEV charging solutions		**8** Charging infrastructure is not ready
9 Trust the market to provide CBEV charging solutions	**CHARGING**	**9** Charging Infrastructure is not fast enough
10 The grid and market will evolve with CBEVs		**10** The electric grid cannot support growth in electric vehicles

NACFE's findings on these 10 arguments are discussed in detail in its Electric Truck Guidance Report

NACFE
NORTH AMERICAN COUNCIL FOR FREIGHT EFFICIENCY

Citations:
[1] Regional Haul, North America Council on Freight Efficiency (NACFE): https://nacfe.org/regional-haul/

[2] Summary of Hours of Service, Federal Motor Carrier Safety Administration, US Department of Transportation: https://cms8.fmcsa.dot.gov/regulations/hours-service/summary-hours-service-regulations

[3] 2019 Annual Fleet Fuel Study, North America Council on Freight Efficiency (NACFE): https://nacfe.org/annual-fleet-fuel-studies/

[4] Electric Trucks—Where They Make Sense, North American Council for Freight Efficiency (NAFCE): https://nacfe.org/future-technology/electric-trucks/.