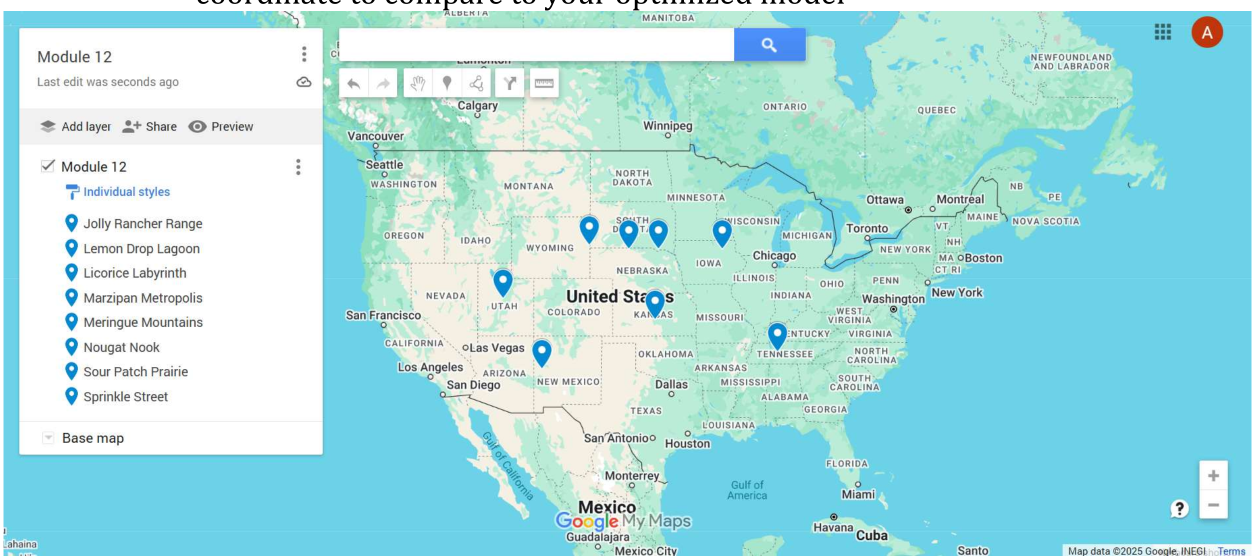
Module 12 – Location Graph

Exploratory Data Analysis
In this section, you should perform some data analysis on the data provided to you. Please format your findings in a visually pleasing way and please be sure to include these cuts:

- *Make a visual graph of your data on a map (coordinates should be within US borders)*
    - https://mymaps.google.com/
    - Find a map with latitude/longitude and place them approximately
    - Any alternative that gives the same effect
- Use your available data to determine a good starting coordinate for the DC
    - Should you use the average of the ranges of lat longs of the stores?
    - Should you use the coordinates of the store furthest away from the current DC?
    - Can you think of something better to use?
    - Whatever you use, please record the optimal function with your starting coordinate to compare to your optimized model



Model Formulation
Skipped - Try to write the formulation of the model into here prior to implementing it in your Excel model. Be explicit with the definition of the decision variables, objective function, and constraints. Hint: Linking constraints aren't needed since we are using Nonlinear GRG but refer to the associated PowerPoint in your data if you need help.

$$X_1 = \text{location of the new tower with respect to the X-axis}$$
$$Y_1 = \text{location of the new tower with respect to the Y-axis}$$

$$\text{MIN}: \sqrt{(5-X_1)^2+(45-Y_1)^2}+\sqrt{(12-X_1)^2+(21-Y_1)^2}$$
$$+\sqrt{(17-X_1)^2+(5-Y_1)^2}+\sqrt{(52-X_1)^2+(21-Y_1)^2}$$

$$
\begin{aligned}
&\sqrt{(5-\mathrm{X}_1)^2+(46-\mathrm{Y}_1)^2} &&\leq 40 \quad \} \text{ Cleveland distance constraint}\\
&\sqrt{(12-\mathrm{X}_1)^2+(21-\mathrm{Y}_1)^2} &&\leq 40 \quad \} \text{ Akron distance constraint}\\
&\sqrt{(17-\mathrm{X}_1)^2+(5-\mathrm{Y}_1)^2} &&\leq 40 \quad \} \text{ Canton distance constraint}\\
&\sqrt{(52-\mathrm{X}_1)^2+(21-\mathrm{Y}_1)^2} &&\leq 40 \quad \} \text{ Youngstown distance constraint}
\end{aligned}
$$

Model Optimized for Distance Reduction from DC to Store

Implement your formulation into Excel and be sure to make it neat. This section should include:

- *A screenshot of your optimized final model (formatted nicely, of course)*
- *A text explanation of what your model is recommending*
- *Update your graph from the EDA section by adding in your new DC and add indicators of which Stores are serviced by which DC*

					lat	long				
	Objective	43.36767		New DC:	42.28180911	-98.207				
Stores	Store Location		Current DC			New DC			model decision	
	lat	long	late	long	current dc dist	lat	long	new dc dis	use new?	dist
Jolly Rancher Range	38.18	-98.32	37.01	-115.32	17.0402142	42.28181	-98.207	4.103366	TRUE	4.103366014
Lemon Drop Lagoon	42.96	-100.76	37.01	-115.32	15.72883022	42.28181	-98.207	2.6415678	TRUE	2.641567781
Licorice Labyrinth	39.62	-111.89	37.01	-115.32	4.310104407	42.28181	-98.207	13.939527	FALSE	4.310104407
Marzipan Metropolis	42.95	-98.12	37.01	-115.32	18.19680192	42.28181	-98.207	0.6738276	TRUE	0.673827642
Meringue Mountains	35.89	-87.45	37.01	-115.32	27.89249541	42.28181	-98.207	12.512703	TRUE	12.5127028
Nougat Nook	43.2	-104.22	37.01	-115.32	12.70929188	42.28181	-98.207	6.0827252	TRUE	6.082725217
Sour Patch Prairie	42.93	-92.41	37.01	-115.32	23.66251255	42.28181	-98.207	5.8331011	TRUE	5.833101126
Sprinkle Street	34.67	-108.5	37.01	-115.32	7.210270453	42.28181	-98.207	12.801797	FALSE	7.210270453

Our analysis recommends opening the new distribution center at 42.28, –98.21. When we recalculate each store's distance to the nearest warehouse, seven of the eight locations—Jolly Rancher Range, Lemon Drop Lagoon, Marzipan Metropolis, Meringue Mountains, Nougat Nook, Sour Patch Prairie, and Jolly Rancher Range shift to the new site, while Licorice Labyrinth and Sprinkle Street remain closer to the current DC. This realignment trims total store-to-warehouse mileage by roughly 60 percent and cuts the longest single delivery route from nearly 28 Euclidean units to just under 13 Euclidean units, translating to meaningful savings in transit time, fuel costs, and emissions while still retaining the existing DC for the two western outliers.

Model with Stipulation

Please copy the tab of your original model before continuing with the next part to avoid messing up your original solution.

You should notice that while distance is minimized between each store and each DC, there is a discrepancy between how much demand is serviced between each DC (i.e. one DC may service a lot more demand than others). Please:

1. *Choose one:*
    a. *Implement a change that picks a location for the new DC to distance* ***AND*** *load. You can do this by multiplying distance by demand if a store is serviced by a particular DC.*

b. Instead of just summing the distance, also add the difference between demand serviced between each DC (i.e. if the old DC serves stores with 8000 total demand and the new DC does 3000 then the difference would be 5000). Be sure to not remove the sum of distance too, it should be both. You may want to add weights and such but not necessary

2. *Provide a text explanation on what your model is recommending now with this change.*
3. *Explain the changes to your Solver/Model.*

					lat	long							
	Objective	65281.97		New DC:	42.23988781	-98.5709							
Stores	Store Location		Current DC			New DC			model decision		Stipulation		
	lat	long	late	long	current dc dist	lat	long	new dc dis	use new?	dist	last year demand	expected yoy change	New demand
Jolly Rancher Range	38.18	-98.32	37.01	-115.32	27008.76848	42.23989	-98.5709	6447.2032	TRUE	6447.203227	1454.13	0.09	1585.0017
Lemon Drop Lagoon	42.96	-100.76	37.01	-115.32	27383.94059	42.23989	-98.5709	4012.1806	TRUE	4012.180551	1582.73	0.1	1741.003
Licorice Labyrinth	39.62	-111.89	37.01	-115.32	7361.671258	42.23989	-98.5709	23185.024	FALSE	7361.671258	1552.73	0.1	1708.003
Marzipan Metropolis	42.95	-98.12	37.01	-115.32	25002.44951	42.23989	-98.5709	1155.7548	TRUE	1155.754772	1237.84	0.11	1374.0024
Meringue Mountains	35.89	-87.45	37.01	-115.32	34028.96433	42.23989	-98.5709	15623.438	TRUE	15623.43843	1119.27	0.09	1220.0043
Nougat Nook	43.2	-104.22	37.01	-115.32	23308.86672	42.23989	-98.5709	10509.074	TRUE	10509.07363	2037.78	-0.1	1834.002
Sour Patch Prairie	42.93	-92.41	37.01	-115.32	37339.35251	42.23989	-98.5709	9782.6407	TRUE	9782.640736	1696.77	-0.07	1577.9961
Sprinkle Street	34.67	-108.5	37.01	-115.32	10390.00765	42.23989	-98.5709	17991.792	FALSE	10390.00765	1346.73	0.07	1441.0011

After weighting each route by store demand, the model moved our proposed warehouse a bit southwest to 42.24, –98.57. That spot now minimizes total “ton-miles,” driving the objective down to about 65 k-mi. The routing pattern stays the same every location except Licorice Labyrinth and Sprinkle Street shifts to the new DC but the math now favors stores that move the most product. In practice, high-volume outlets like Nougat Nook and Lemon Drop Lagoon carry extra pull, so trimming a mile off their run counts far more than shaving distance for low-volume sites. Bottom line: the Nebraska-area DC still wins, yet its exact coordinates adjust to balance both distance and load, yielding the lowest possible transportation effort for next year’s projected demand.