HIGH SCHOOL

RAILROAD MODEL COMPETITION

MANUAL

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Transportation Institute

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HIGH SCHOOL RAILROAD MODEL COMPETITION

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FRESNO STATE TRANSPORTATION INSTITUTE

Created in 2017 to advance transportation sciences in Fresno County, the Institute results from a unique collaboration between the California State University, City of Fresno and the Fresno Council of Governments and funded through Fresno County's Measure C New Technology Reserve Fund.

In accordance with the Regional Transportation Plan and Sustainable Community Strategy, the Institute has the mission of instigating and developing transportation projects in the following areas:

Education: through courses, training, workshops, and conferences, the Institute seeks to develop and offer advanced education programs to create a skilled workforce that can potentially advance the city and regional transportation planning and other transportation-related fields.

Outreach: to better educate about the importance of local transportation solutions and increase the acceptance for advanced transportation projects in the Fresno County, the Institute organizes games, competitions and other events aimed at K-12 students and the general public.

Research: through the collaboration with graduate and undergraduate programs at Fresno State and other academic partners across the Central Valley, the Institute incentivize research projects that seek solutions to the unique transportation challenges faced by Fresno County and its neighbors, such as reduced mobility, poor air quality, traffic congestion, and high energy demand.

Technical Service: to facilitate the pursuit of transportation-related projects by local agencies and firms, the Institute provides resources and technical expertise to help its partner organizations prepare and submit proposals for obtaining project grants and other funding.

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PARTICIPANTS INFORMATION

Fill out the information bellow and let us know more about you!

SCHOOL NAME: _____

GRADE LEVEL: _____

TEAM MEMBERS (UP TO 10)

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

MENTORS (UP TO 3)

_____

_____

_____

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1. INTRODUCTION

1.1 ABOUT US

The Fresno State Transportation Institute designed the Railroad competition to be an accessible, guided, and enjoyable educational competition, helping students and teachers to build a better future in transportation sciences.

The competition starts with a question - **How does transportation infrastructure affect the population and the economy?**

With that question in mind, students will be exposed to real engineering problems to stimulate their critical thinking by applying math and science concepts to design, build, research, and propose solutions to the challenges.

The students will learn how to play a role on an engineering team and develop project management skills by task distribution and time management. The competition is divided into three main sections:

RESEARCH AND PRESENT

Write and present a research paper about the history, current situation, and future plans of railroads in the US.

DESIGN AND BUILD

Design a railroad model that connects cities throughout California and Nevada.

OPERATE AND COMPETE

Operate the model on the competition day, and compete against other model designs.

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1. INTRODUCTION

1.2 CORE VALUES

The Railroad Competition is committed to encouraging students to learn and practice our core values:

- **INTEGRITY** Sportsmanship and fair play.
- **DISCOVERY** Develop innovative solutions to solve the problems.
- **LEARNING** Research about key subjects in transportation science.
- **DIVERSITY** Create a positive culture with inclusion, dignity, and respect for all.

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2. RESEARCH AND PRESENT

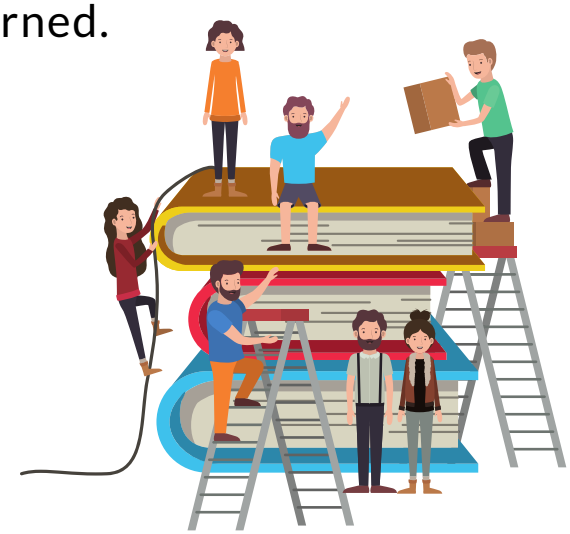
2.1 RESEACH TOPIC

"Past, Present, and Future of the Railroads in the USA"

Minimum number of pages: 15

It should be written in a simple language, understandable for all high school students.

- Demonstrate critical thinking, not just reporting facts that you gathered.
- If possible, explain how the topic has evolved over the years and its implications for the future.
- Explain your main ideas in detail with supporting information.
- Prepare a 10-minute presentation about what you learned.



2.2 RESEARCH PAPER GUIDELINES

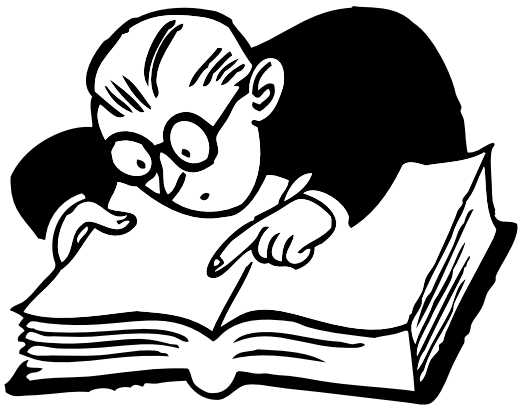
Introduction

The introduction should be able to attract the reader's attention and explain the focus of the research.

Literature Review

The purpose of the literature review is to describe examples of previous important research and how it specifically relates to the research thesis by answering the following questions:

- How are railroads important to the United States?
- How did railroads affect life in the United States?
- What's the history of the railroads in the United States?
- What role do railroads play in the economy?
- How did the railroad change human behavior?



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2. RESEARCH AND PRESENT

Research Analysis

In this section, write an analysis of the potential benefits of the new California high-speed rail that will connect the mega-regions of the state. Tell us how this transportation project will affect California residents' life.

Tip: Think about the economic development contribution and conditions for a cleaner environment, job creation, and preservation of agricultural and protected lands. Explain the role of the new high-speed rail towards the benefits you listed.

Conclusion

What have you learned from the research? Try to include some suggestions or advice that could be helpful to encourage railroad use.

References

Present research references.

2. RESEARCH AND PRESENT

2.3 PRESENTATION GUIDELINES

Based on the written research paper, each group will develop a 10-minutes PowerPoint presentation that will summarize what they learned.

The **title slide** should Include the topic, participants' names, the name of the school, and the date.

Also, please include:

- **Introduction** (1 to 2 slides)
- **Literature Review** (4 to 5 slides)
- **Research Analysis (** 4 to 5 slides)
- **Conclusion** (1 to 2 slides)
- **References** (1 slide)

If you use text, use **bullet points**, not big sentences.

The slides are for the audience; **tell the story of your topic** with the use of images.

Be creative in grabbing and maintaining attention!

Practice out loud!

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3. DESIGN AND BUILD

3.1 LET'S GET STARTED!

- Divide students into groups of 8 to 10 people. Each group will be an engineering company, so be creative in deciding a good name for your engineer's team!

- Teamwork teaches students how to respectfully and confidently express their ideas and opinions effectively in a group setting. This challenge will give them an opportunity to make decisions together, starting from choosing the railroad track path!

- When choosing the path and placing the railroad track on the map, the teams will have to calculate the overall cost, which consists of the addition of costs of Land and Construction.

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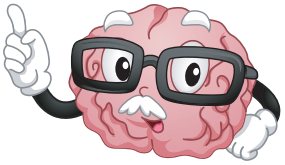
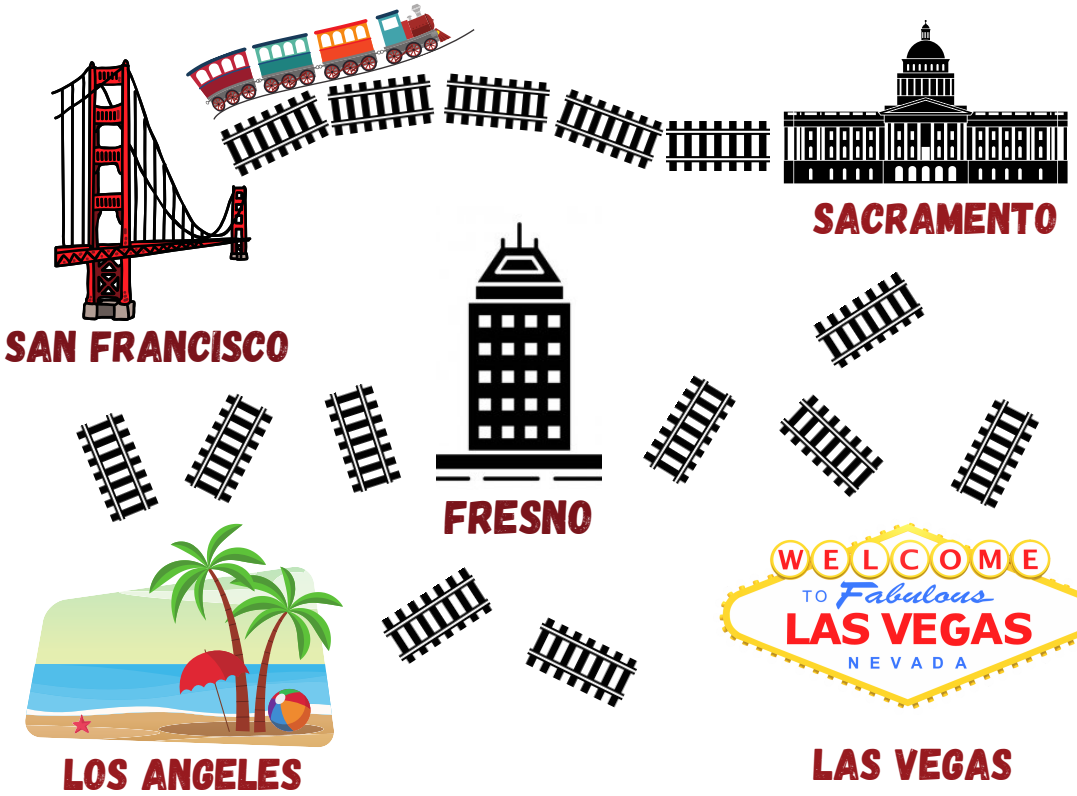
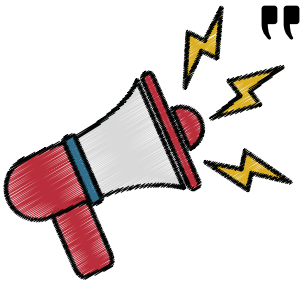
3. DESIGN AND BUILD

3.2 GOAL

The goal of this challenge is to build a railroad that connects the following cities in such a way as to minimize the total cost and maximize the total revenue.







"Every time a train travels from city A to city B. The trip creates an income that will result in your revenue at the end. Refer to the "Origin-Destination Profit Matrix" to find the highest profit out of a trip and make a stop at all the cities in the shortest time!"

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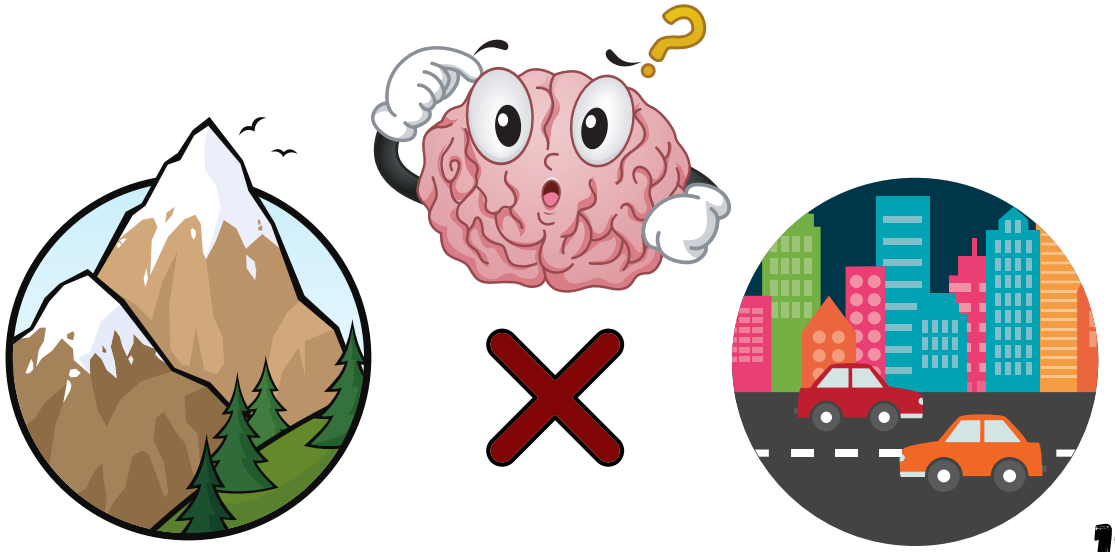
3. DESIGN AND BUILD

3.3 COST CALCULATION

- The map is divided into 2" x 2" cells, which have different terrains and land prices.

- The cost of the land will vary depending on the location. For example, if the land is in a forest, the cost might be less than in a city. On the other hand, depending on the topography (mountains and valleys), the cost of construction, operation, and maintenance may increase.



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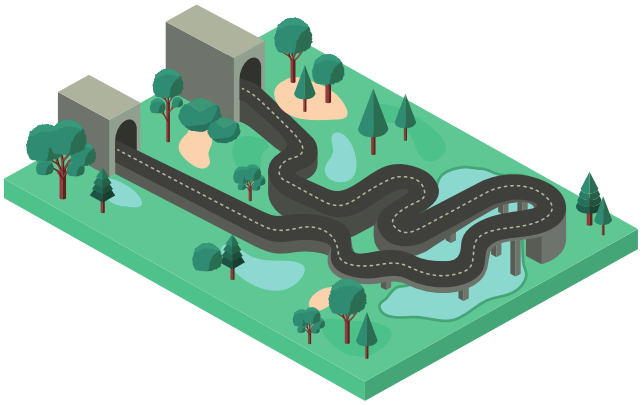
3. DESIGN AND BUILD

- The same reasoning applies to the regions with a river or a mountain where the additional construction of a bridge or a tunnel is required.



- Think about environmental aspects, such as ecosystem preservation and indigenous tribes' protection.

These are just examples of situations that you and your team will be exposed to. The optimal path consists of the fastest and less expensive path considering the environmental protection aspects.

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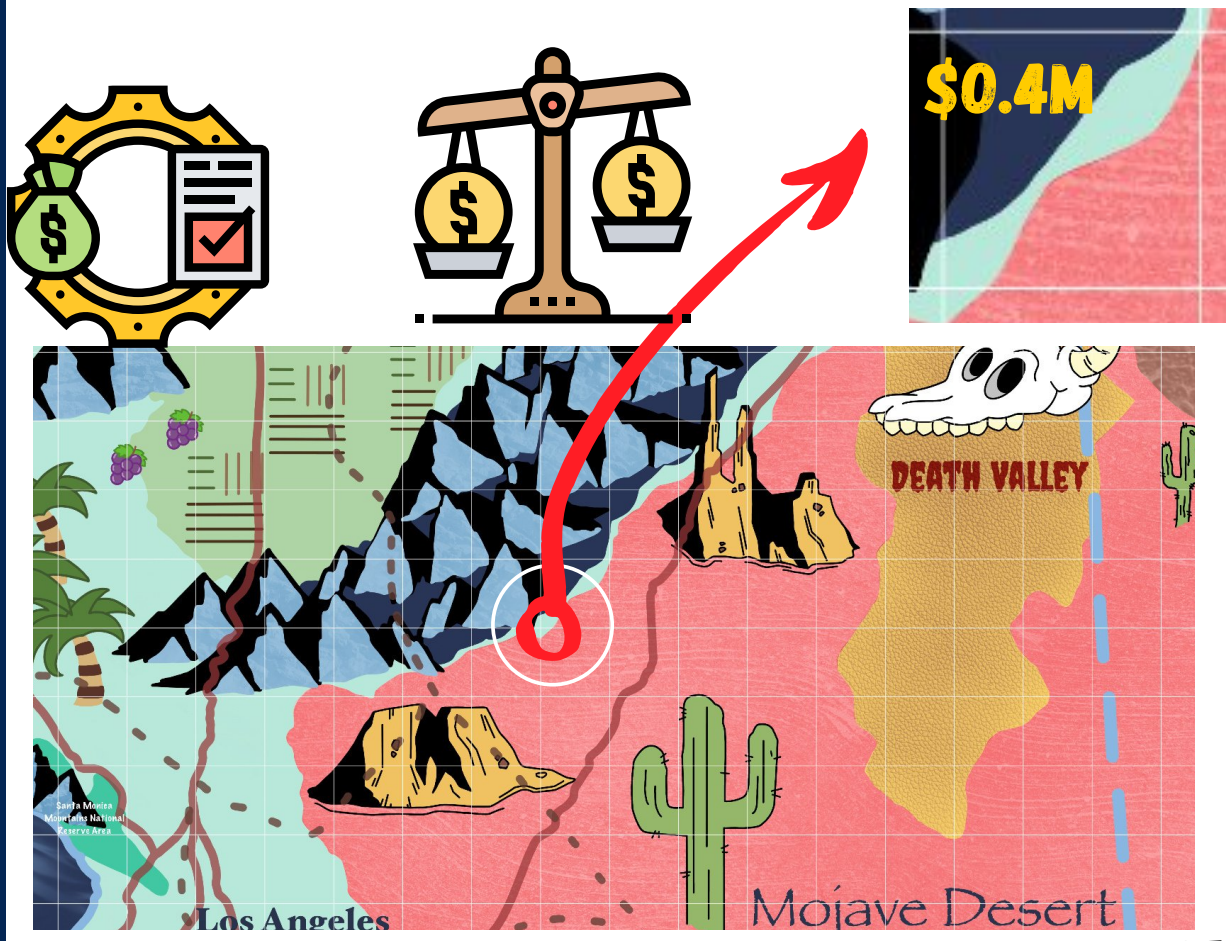
3. DESIGN AND BUILD

3.4 COST OF LAND

Cost estimation is an essential part of engineering projects. Not only are estimates vital to your project budget, but also to your job schedule and how you manage your resources!

In this challenge, your team will have to calculate the cost of land, construction, operation, and maintenance. The Map is divided into 2"x2" cells. For the cost of land, on the top left of each cell is displayed the individual cost for the cell as shown in the image bellow.



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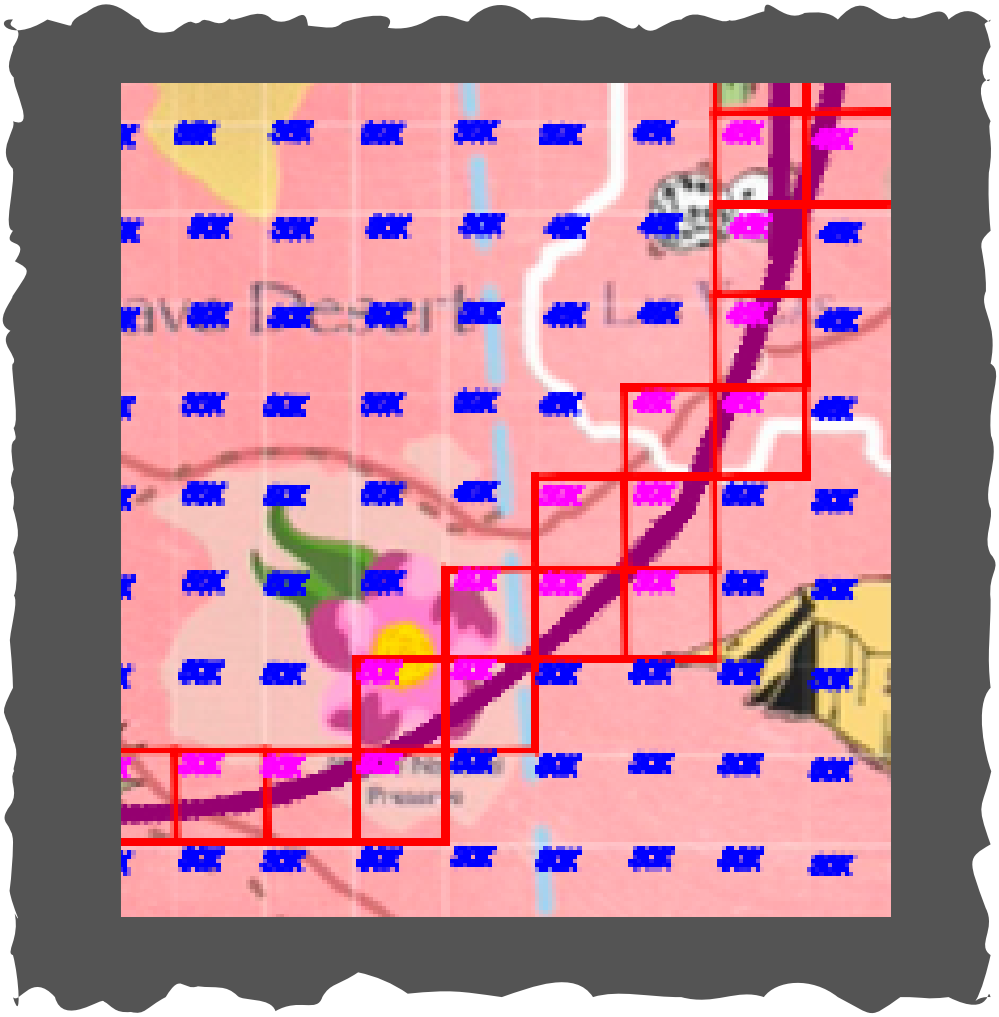
3. DESIGN AND BUILD

Once you have determined your railroad path, you will be able to identify the cells occupied by the tracks and add their values to estimate the total cost of land.



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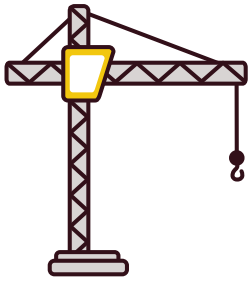
3. DESIGN AND BUILD

3.5 OTHER COSTS

After you have estimated the cost of land, the next step is to calculate the cost of construction, operation and maintenance.

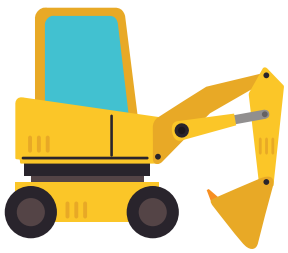
The table below contains the unit cost of construction and maintenance according to the type of terrain. This table is very important, and you will constantly be consulting it to estimate each one of the following costs*



	FOREST	CITY	DESERT	MOUNTAIN	RIVER
CONSTRUCTION	$4.0 M	$3.5 M	$1.5 M	$6.0 M	$5.0 M
MAINTENENCE	$550 K	$560 K	$580 K	$600 K	$590 K

Note: The values on the construction line are in millions ($4.0 M = $4,000,000) and values on the maintenance line are in thousands ($550 K = $550,000).

Note: 1" on the map is equal to 7 miles in reality.



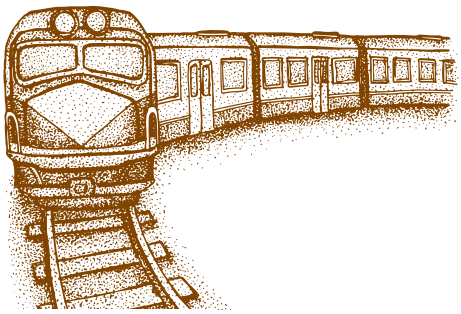
***Disclaimer: All values on this manual are rough estimates and do not accurately reflect real-life costs.**

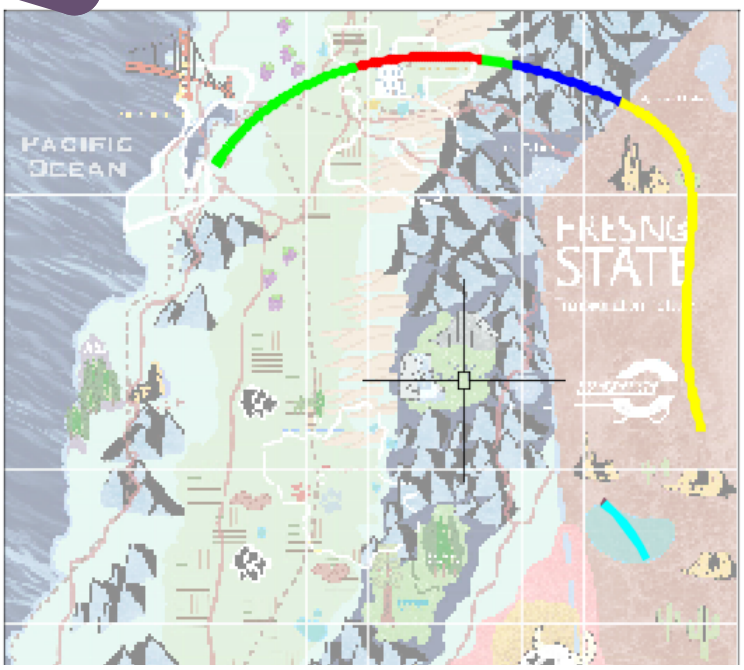
3. DESIGN AND BUILD

3.5 OTHER COSTS

This section will go over the steps you need to estimate the construction, operation, and maintenance costs.

Let's begin with an example: Consider that the image below represents some fragments of railroad your team placed into the map. The green is a track section passing through the forest, the red, the track section within the city boundary, the blue, a section going across the mountains, the yellow into the desert, and the cyan, a river (water section).





3. DESIGN AND BUILD

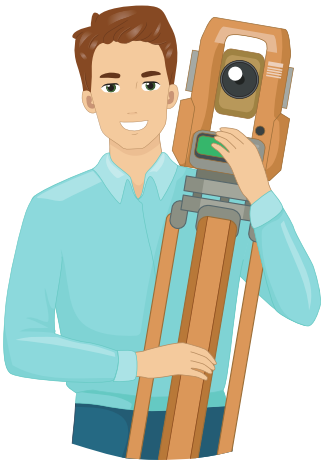
3.6 CONSTRUCTION COST

Construction cost estimating is the process of forecasting the cost of building a physical structure, in this case, the railroad track.

The question is: What length each section of the track is occupying on the map?

Tip: Measure the length of each track section using a thread and add them up according to the type of terrain.

How can we measure distance on a map?

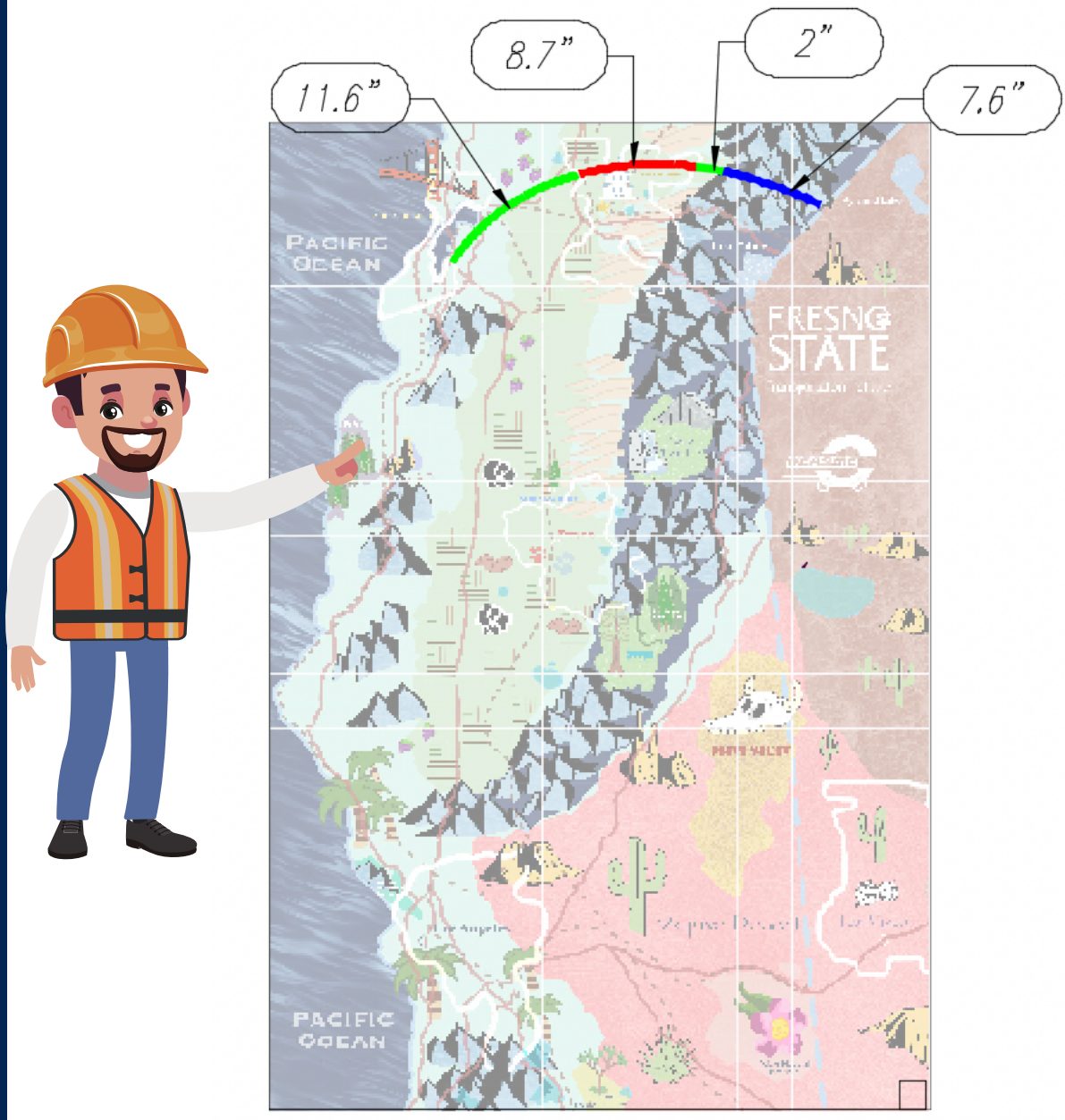


Use a string to measure the railroad track distance. Keep in mind that the type of terrain will influence the unit length cost of construction.

3. DESIGN AND BUILD

3.6 CONSTRUCTION COST

The following example presents the track length of different sections categorized by the type of terrain. By adding up these values, you will find out the total track length of forest, desert, mountains, city, and water. Let's say the overall length of the forest was 13.6.", then you have to multiply it by the value found in the cost table.



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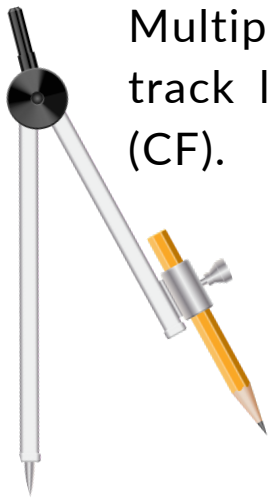
3. DESIGN AND BUILD

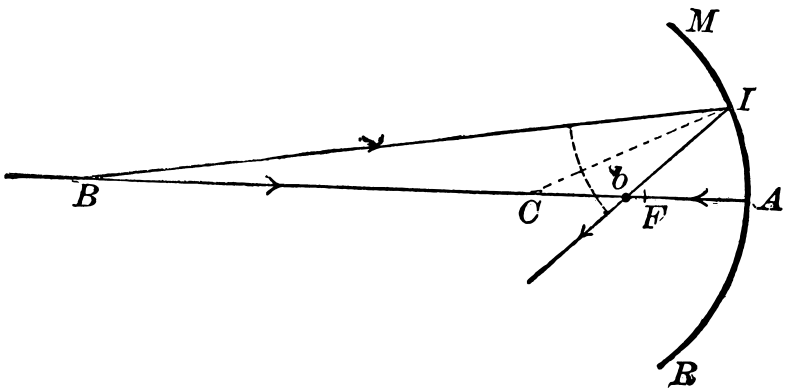
3.7 MAINTENANCE COST

Maintenance of railroad means inspecting, repairing, and maintaining railway tracks to keep the trains running smoothly and safely so as to prolong the service life. The cost of maintenance is a function of the curvature. Meaning that the cost to maintain a straight segment is cheaper than the cost to maintain a curvilinear segment with a small radius. See specifications:

SEGMENT	FACTOR
Small Radius (Min =15" - Max =20")	**CF = 2**
Moderate Radius (Above 20" and Bellow 40")	**CF = 1.5**
Great Radius/ Straight segment (Above 40")	**CF = 1**



Multiply the cost of maintenance for each track length segment by the curvature factor (CF).



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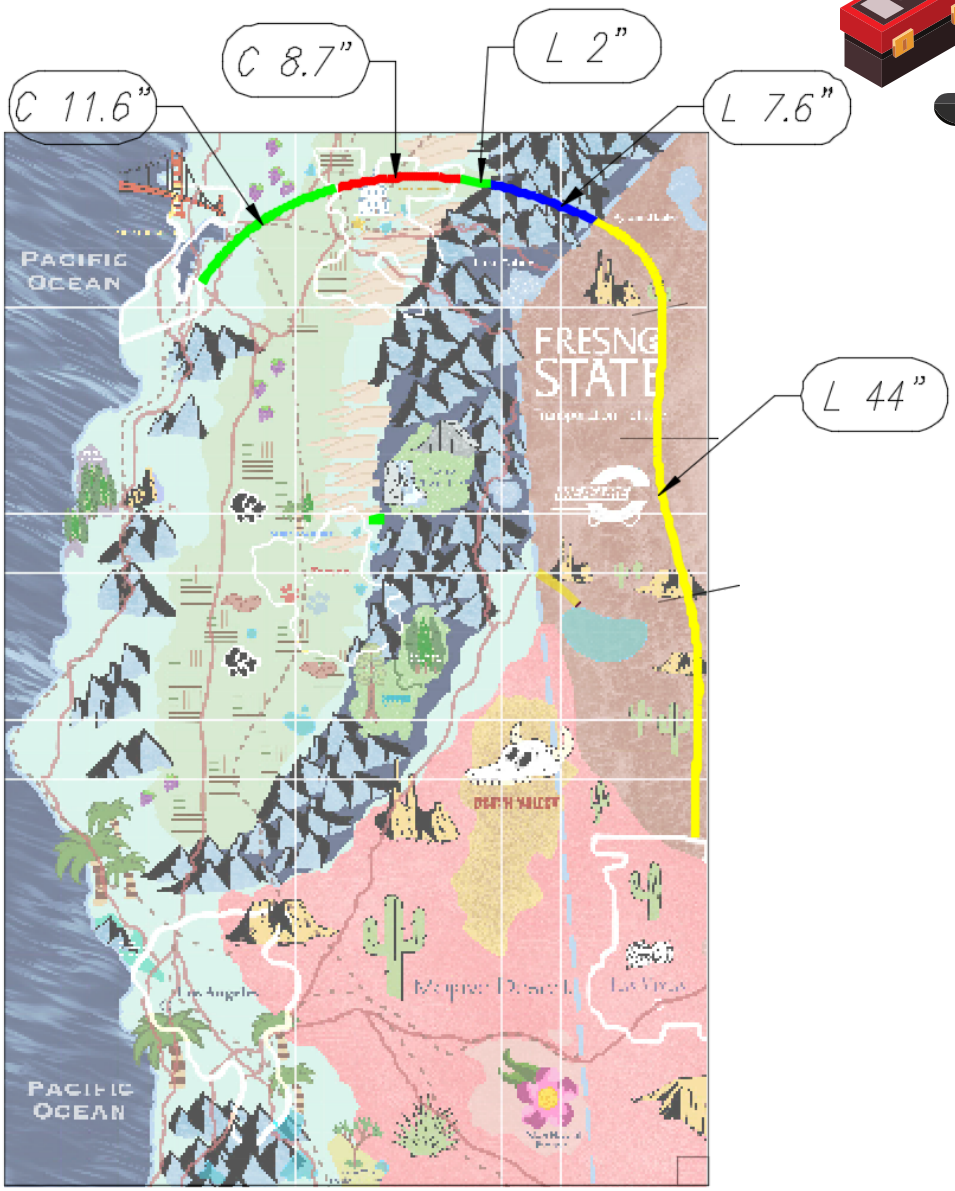
3. DESIGN AND BUILD

3.7 MAINTENANCE COST

Identify and separate the linear and curvilinear segments, then estimate the length of each section. For the curves, measure the radius and apply the curvature factor-related to obtain the cost.



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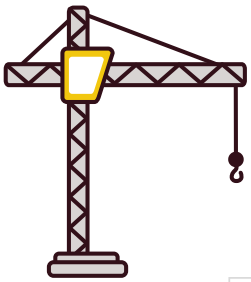
3. DESIGN AND BUILD

3.7 MAINTENANCE COST

For example, let's say that you found out that the radius of the curvilinear segment in a forest is 25", in this case, the curvature factor would be 1.5, the curve length is 11.6' and the maintenance cost (Forest unit) is $ 550k.

MAINTENANCE COST = **MAINTENANCE (FOREST UNIT)** X **CURVE FACTOR** X **CURVE LENGTH**



	FOREST	CITY	DESERT	MOUNTAIN	RIVER
MAINTENENCE	$550 K	$560 K	$580 K	$600 K	$590 K

MAINTENANCE COST = $ 550,000 X 1.5 X 11.6

MAINTENANCE COST = $ 9,570,000

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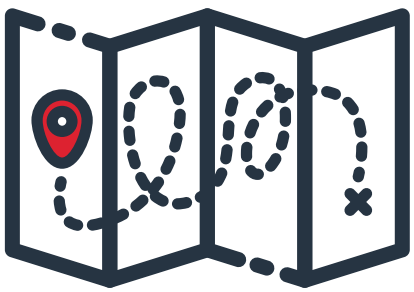
4. OPERATION AND COMPETE

4.1 OPERATION COST

Railway operation cost is the calculation of rail movements. Two factors are taken into consideration for this cost estimation. The first one is the rolling stock, which configures the number of vehicles that move along a railway, including powered and unpowered vehicles such as locomotives, railroad cars, and passenger cars. The second factor is the route that these vehicles are traveling. Because of these factors, the operation cost is calculated in VMT (Vehicle-Mile-Traveled).

To calculate the operation cost, you need to create a train timetable. This table will contain all the departures and arrivals times in a 4 min timeframe, with an obligatory waiting time of 10 seconds in each train station for appropriate loading and unloading of passengers and cargo.

By knowing the complete possible route of said 4 min, you will be able to identify the total of miles traveled.
The VMT price is $400 for non-mountainous segments and $600 for the mountainous ones, in which 1" on the map is approximately equal to 7 miles in reality.



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4. OPERATION AND COMPETE

4.2 TIME SCHEDULE TEMPLATE

Time Schedule Table				
Departure City	Arrival City	Departure	Arrival	Waiting time
Fresno	Las Vegas	0:00:00	0:00:17	0:00:10

The timetable above will be helpful not only for the operating cost estimate but also for the revenue. Complete the timetable itinerary in the best way to maximize the total revenue and minimize the total costs.

Tip: Do many simulations, test different travel speeds, and have fun!

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4. OPERATION AND COMPETE

4.3 REVENUE

ORIGIN – DESTINATION PROFIT MATRIX

The "Origin-Destination Profit Matrix" specifies the prices of each trip among the cities to be connected in this challenge. Use the table to calculate your profit!

	FRESNO	LAS VEGAS	LOS ANGELES	SACRAMENTO	SAN FRANCISCO
FRESNO		$136K	$120K	$104K	$112K
LAS VEGAS	$136K		$128K	$184K	$200K
LOS ANGELES	$120K	$128K		$165K	$144K
SACRAMENTO	$104K	$184K	$165K		$92K
SAN FRANCISCO	$112K	$200K	$144K	$92K	

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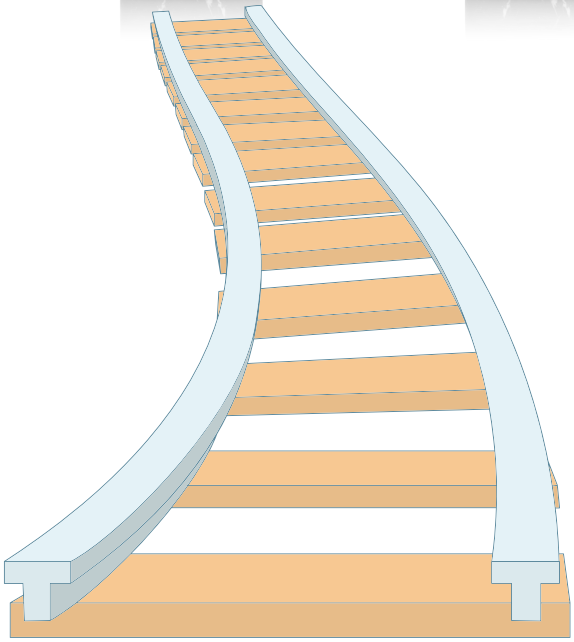
5. AWARDS AND TROPHIES

The Fresno State Transportation Institute will be rewarding the student's team that has not only designed the best solution for the railroad model but has also operated it properly.

Alongside the model construction and operation, part of the evaluation is related to the research paper and good presentation.



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6. PROJECT MATERIALS

LOCOMOTIVE

Bachmann Industries Alco S4 Diesel Switcher Dcc Equipped Locomotive ATSF #1528 (Zebra Stripe) N Scale Train Car.

BACHMANN INDUSTRIES N-SCALE PASSENGER CAR

Bachmann Industries Smooth Side Coach Union Pacific N-Scale Passenger Car, 85'

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6. PROJECT MATERIALS

ATLAS 2500-10 CODE 80 SUPER-FLEX 30" TRACK SECTION (10 PIECES)

Easy to use and affordable, you will find that Atlas N scale Code 80 track with black ties and nickel silver rail is built to last for ultimate performance.

TRACK NAILS

Peco SL-14 N Scale Track Nails

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6. PROJECT MATERIALS

REMOTE RIGHT-HAND SWITCH

N Code 80 Nickel Silver #6 Remote Switch Right Atlas Trains

REMOTE LEFT-HAND SWITCH

ATL2704 N Code 80 #6 Remote Left-Hand Turnout

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6. PROJECT MATERIALS

ATLAS N CODE 80 NICKEL SILVER RAIL JOINERS (6/CD) TRAINS

The joiners are used to connect the track sections

N SCALE RAIL JOINERS WITH WIRE

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6. PROJECT MATERIALS

BACHMANN INDUSTRIES E Z COMMAND DCC CONTROLLER

1"X4'X8' FOAM BOARD

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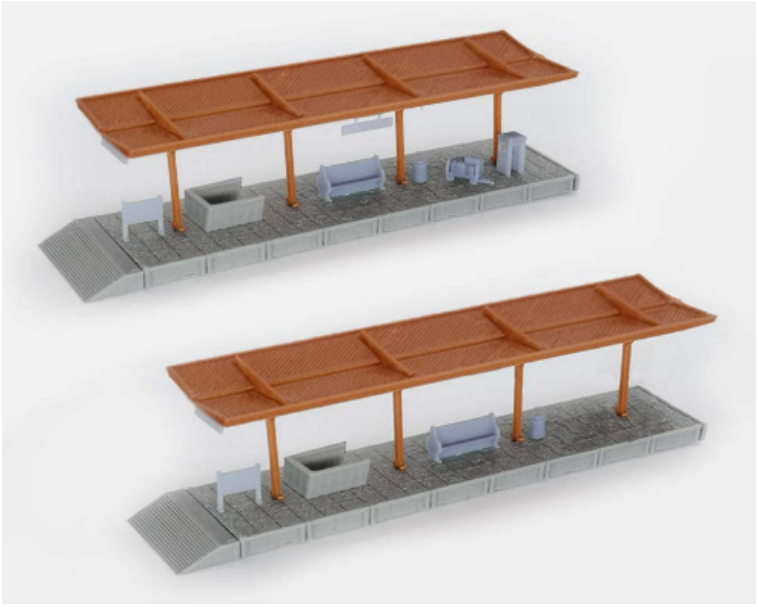
6. PROJECT MATERIALS

CUTTERS – XURON MAXI-SHEAR FLUSH CUTTER – SEMI FLUSH 2175B

TRAIN STATION PASSENGER PLATFORM



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6. PROJECT MATERIALS

MIXED MODEL TRAIN TREES

PLASTIC ROCKERY TUNNEL TRACK TRAIN

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MEASURE

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