



MIDDLE SCHOOL

RAILROAD MODEL COMPETITION

MANUAL

FRESNO STATE[®]

Transportation Institute



**MIDDLE
SCHOOL**

**RAILROAD
MODEL COMPETITION**

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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.

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)**



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?

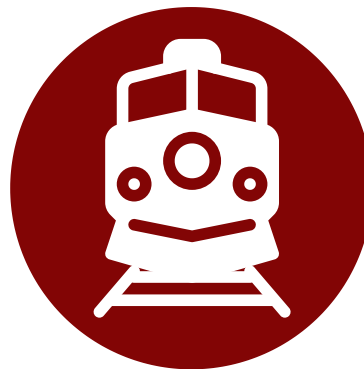
With that question in mind, students will be exposed to real engineering problems to stimulate their critical thinking by applying math and science concepts to design, build, research, and propose solutions to the challenges.

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.

1. INTRODUCTION

1.2 CORE VALUES

The K-12 Competition of the Fresno State Transportation Institute is committed to encouraging students to learn and practice our core values:

-  **INTEGRITY** Sportsmanship and Fair Play.
-  **DISCOVERY** Research and develop new skills by documenting and presenting your discoveries.
-  **LEARNING** Learn about Transportation Sciences
-  **DIVERSITY** Create a positive culture with inclusion, dignity, and respect for all



2. RESEARCH AND PRESENT

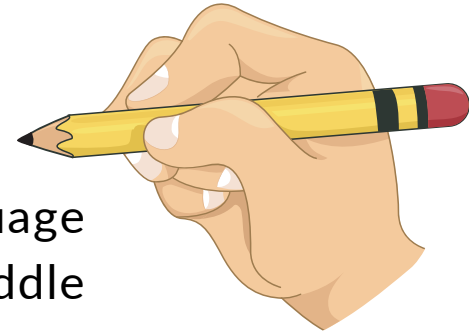
➤ 2.1 RESEARCH TOPIC:

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

Minimum Number Pages:10

It should be in a simple language understandable for all middle students.

- Demonstrate critical thinking, not just reporting facts that you gathered.
- If possible, include 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. RESEARCH AND PRESENT

➤ 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:

- 1) How are railroads important to the United States?
- 2) How did railroads affect life in the United States?
- 3) What's the history of the railroads in the United States?

Conclusion

What have you learned from the research? Try to include some suggestions or ideas 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-minute 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)
- **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!

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!

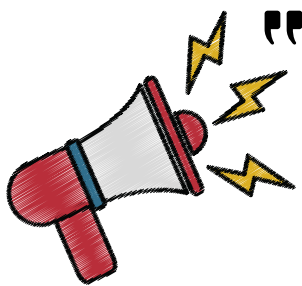
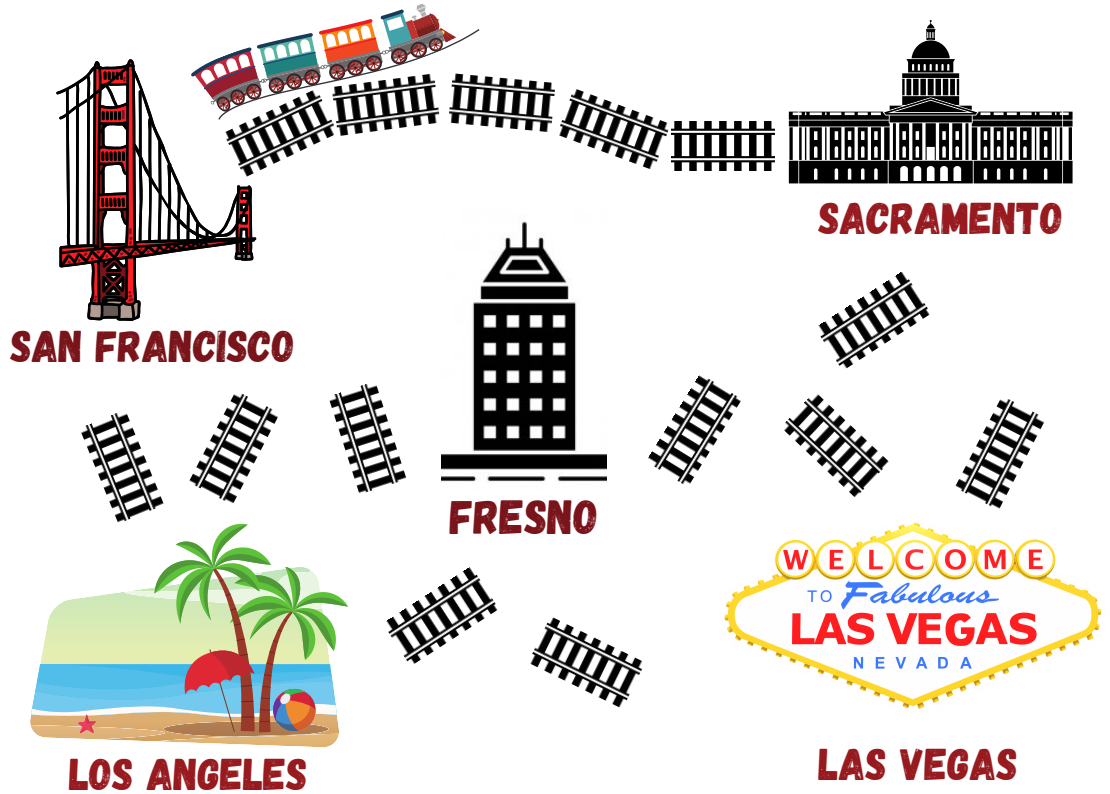
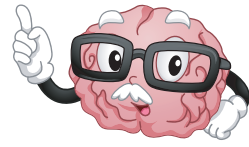


- ▶ Teamwork teaches students how to respectfully and confidently express their ideas and opinions effectively in a group setting. This challenge will give them an opportunity to make decisions together, starting from choosing the railroad track path!
- ▶ When choosing the path and placing the railroad track on the map, the teams will have to calculate the overall cost, which consists of adding costs of Land, Construction, Operation, and Maintenance of the Railroad.

3. DESIGN AND BUILD

3.2 GOAL

▶ The goal of this challenge is to build a railroad that connects the following cities:



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!

”

3. DESIGN AND BUILD

3.3 COST ESTIMATION

- Cost estimation is a very important part of an engineering project. How you distribute your resources affects your results and can prevent you from wasting materials, money, and time.

In this challenge, the total cost estimation is broken down into four principal costs: Land, Construction, Maintenance, and Operation.

3.4 COST OF LAND

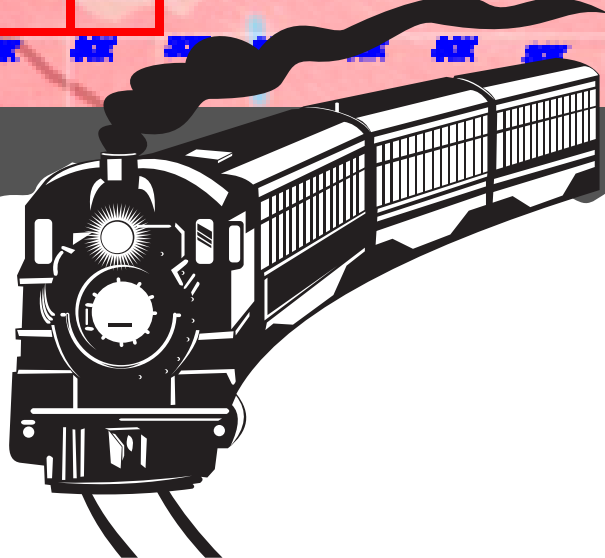
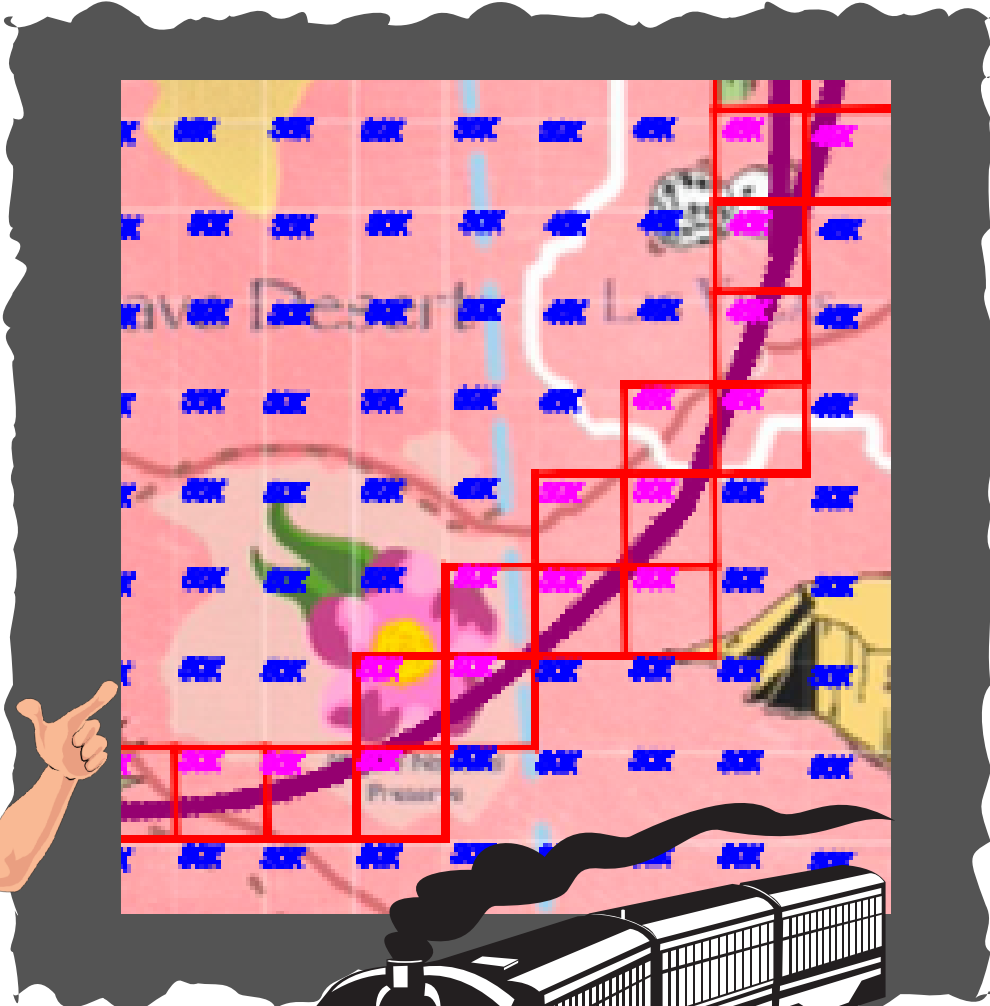
Each cell of the map shows its specific price, which varies from location to location, depending on many factors, including social and environmental aspects.



3. DESIGN AND BUILD

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- 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 for the subject project.

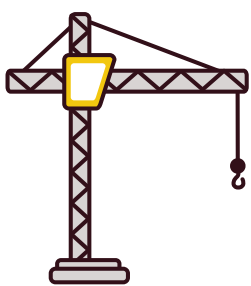


3. DESIGN AND BUILD

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.

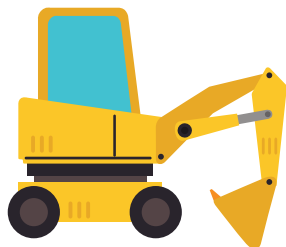
The table below contains the unit cost of construction and maintenance according to the type of terrain. This table is very important, and you will constantly be consulting to estimate each one of the following costs*



	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

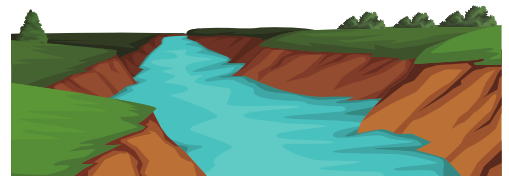
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▶ 3.6 CONSTRUCTION COST

When building a railroad, one of the most important aspects to consider is the track length. Think about it, if you are going from a point "A" to a point "B" you need to know the distance between them.

The shortest distance between two points is a line, but not always building a straight segment is the best option, which can be due to different reasons. There can be indigenous tribes on the way or an area of animal and environmental protection, for example.

To estimate the construction cost, you will need to multiply the length of the track by a correspondent value of the type of terrain.

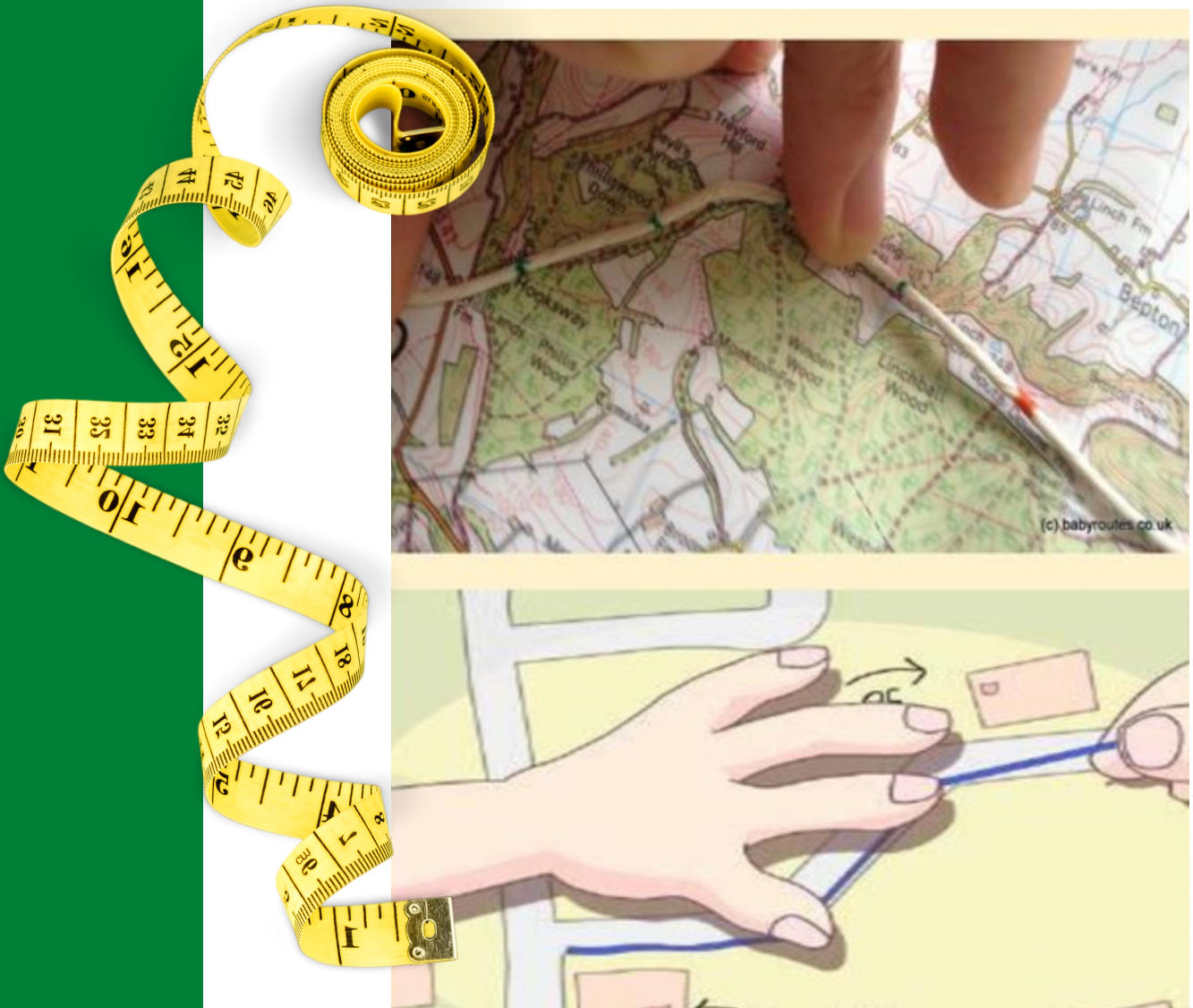


3. DESIGN AND BUILD

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How to measure distance on a map?

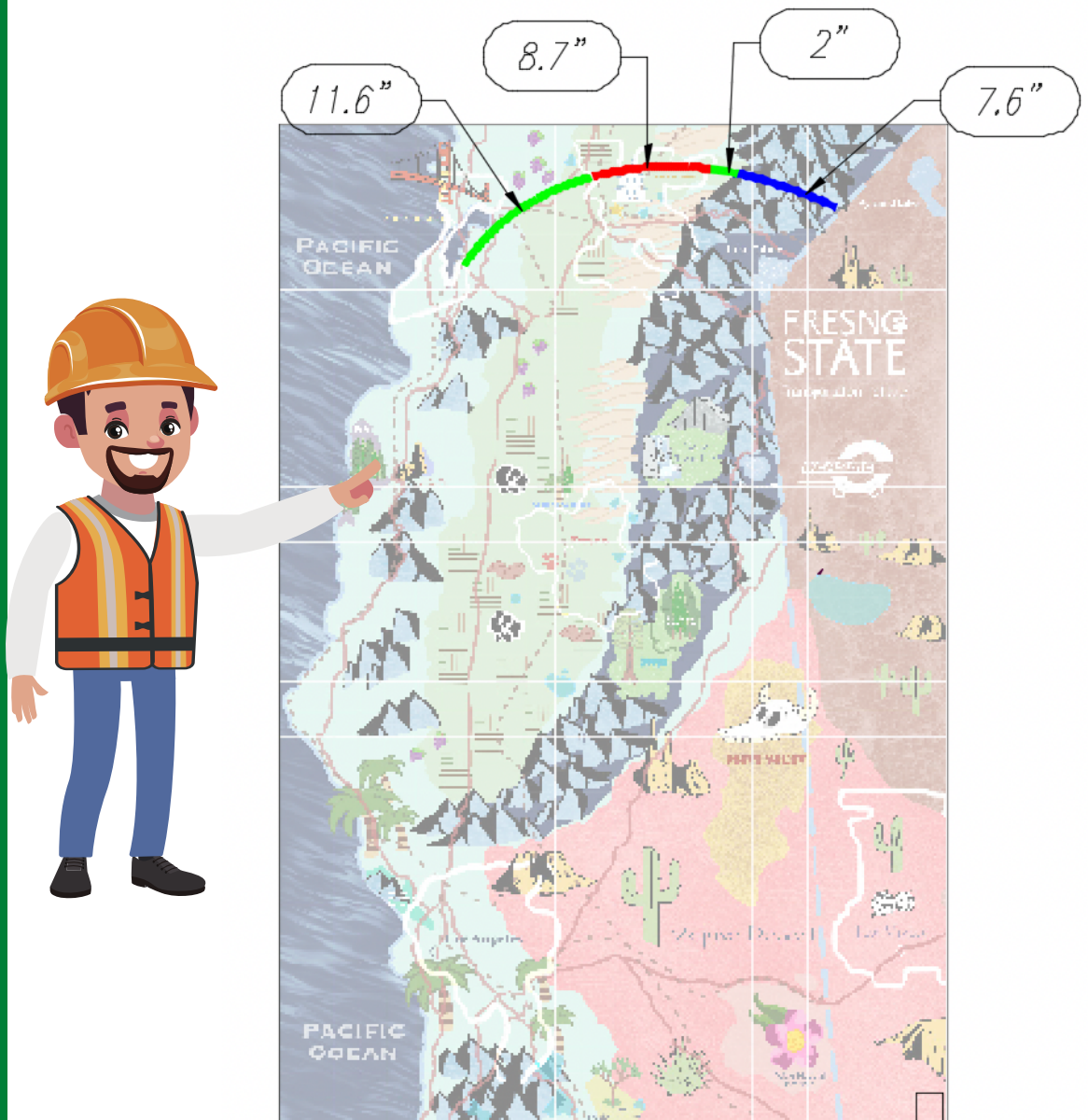
Use a string to measure the railroad track distance by aligning it along the centerline of the road. Then, with a measuring tape, get the length.



3. DESIGN AND BUILD

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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.

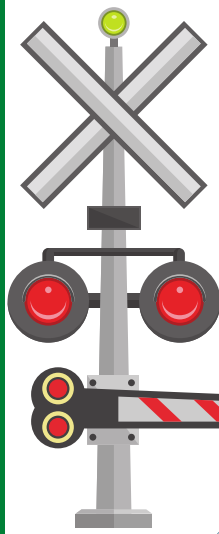
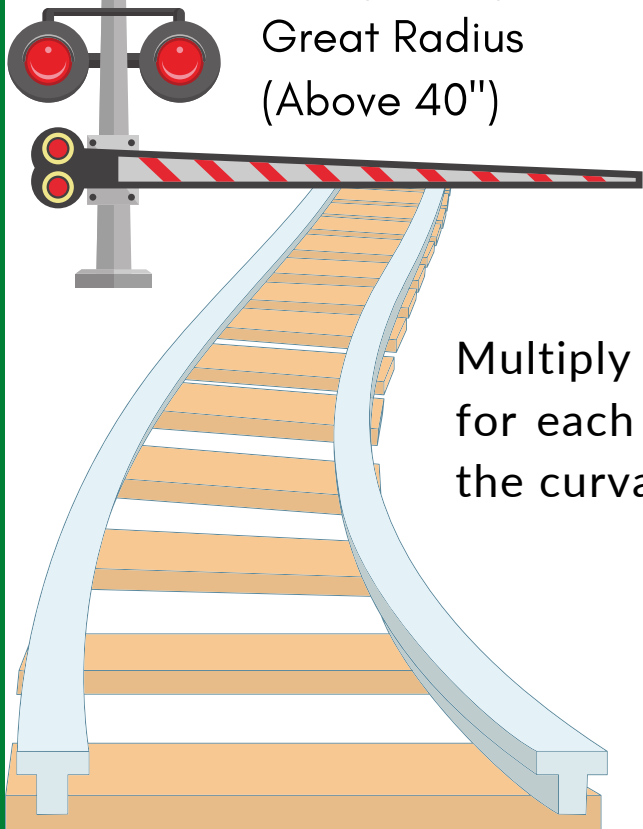


3. DESIGN AND BUILD

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3.7 MAINTENANCE COST

Rail track maintenance means inspecting, repairing, and maintaining railway tracks to keep the trains running smoothly and safely 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 less than the cost to maintain a curvilinear segment. See specifications in the table below:

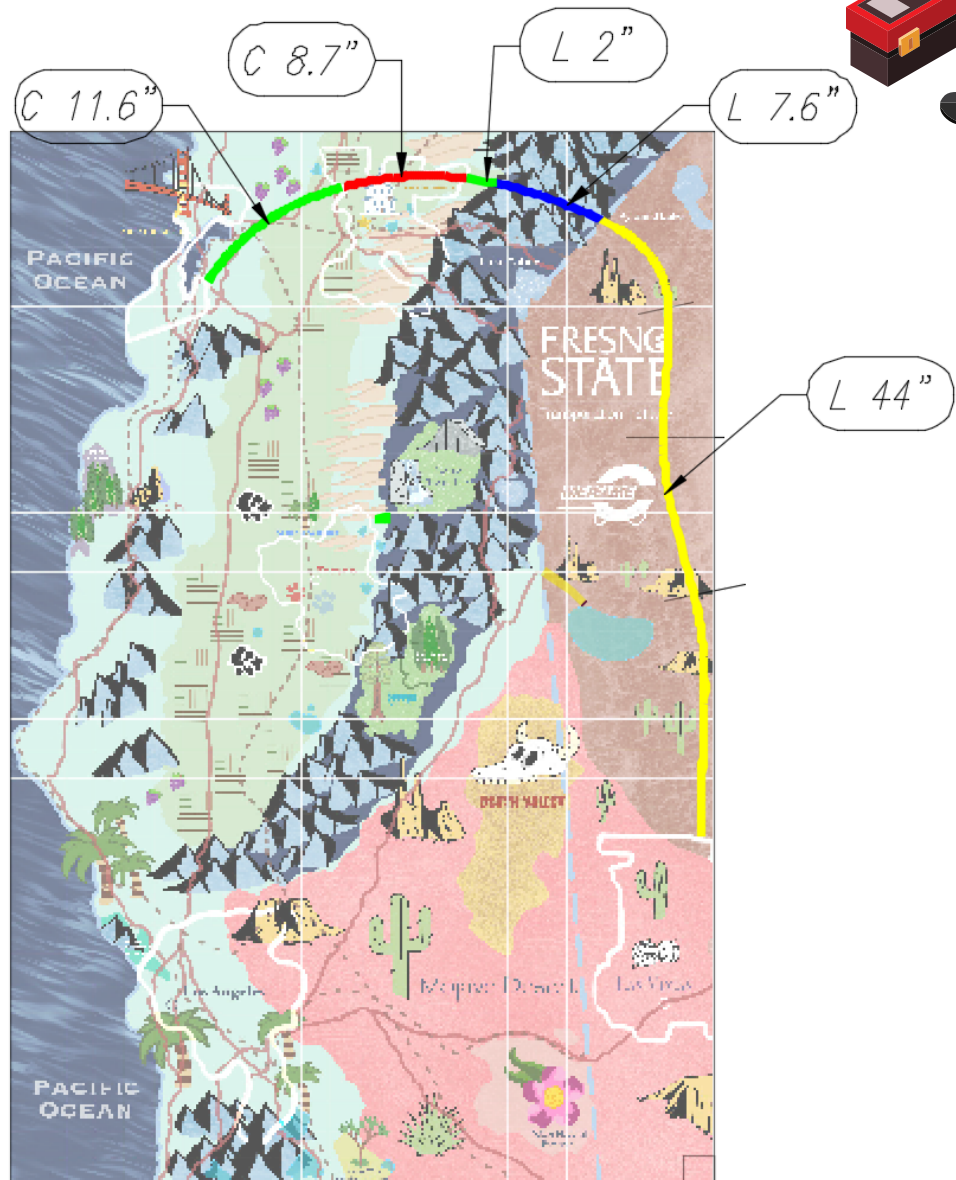
SEGMENT	FACTOR
 Curvilinear Segment	CF = 2.0
 Straight Segment / Great Radius (Above 40")	CF = 1.0

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

3. DESIGN AND BUILD

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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.

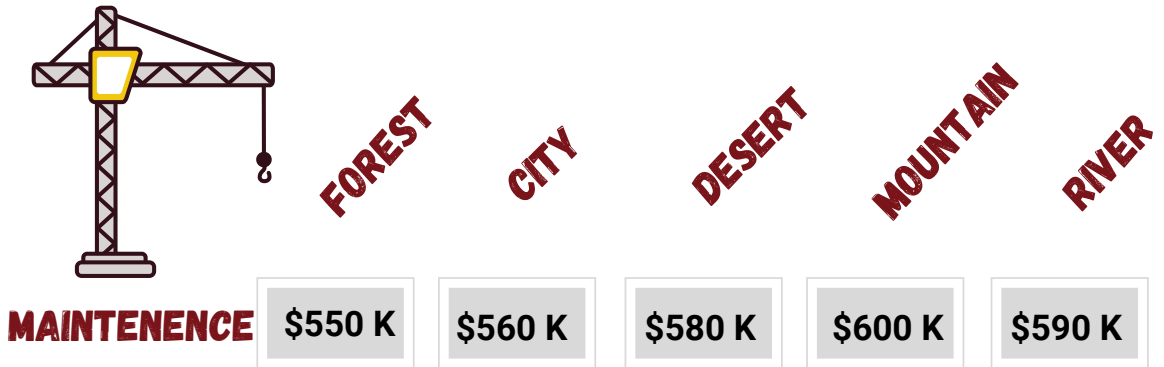


3. DESIGN AND BUILD

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For example, let's say that you found out that radius of the curvilinear segment in a forest is 25", in this case, the curvature factor would be 2.0, the curve length is 11.6' and the maintenance cost (Forest unit) is 550k.

$$\text{MAINTENANCE COST} = \text{MAINTENANCE (FOREST UNIT)} \times \text{CURVE FACTOR} \times \text{CURVE LENGTH}$$



$$\text{MAINTENANCE COST} = \$ 550,000 \times 2.0 \times 11.6$$

$$\text{MAINTENANCE COST} = \$ 12,760,000$$



4. OPERATION AND COMPETE

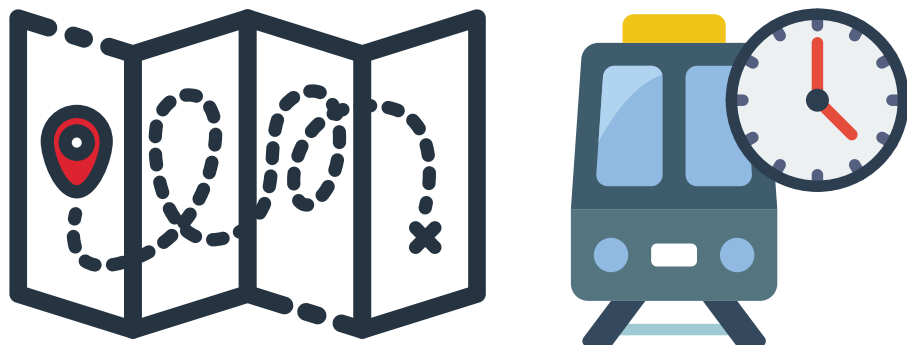
4.1 OPERATION COST

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 time-frame of 4 min time-frame, 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 \$500" on the map is approximately equal to 7 miles in reality.



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!



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!



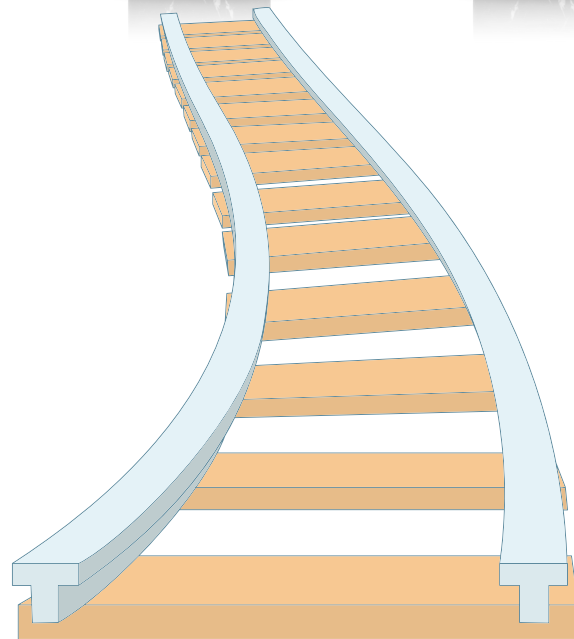
	FRESNO	LAS VEGAS	LOS ANGELES	SACRAMENTO	SAN FRANCISCO
FRESNO		\$136K	\$120K	\$104K	\$112K
LAS VEGAS	\$136K		\$128K	\$184K	\$200K
LOS ANGELES	\$120K	\$128K		\$165K	\$144K
SACRAMENTO	\$104K	\$184K	\$165K		\$92K
SAN FRANCISCO	\$112K	\$200K	\$144K	\$92K	

5. AWARDS AND TROPHIES

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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.



6. PROJECT MATERIALS

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LOCOMOTIVE



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



BACHMANN INDUSTRIES N-SCALE PASSENGER CAR

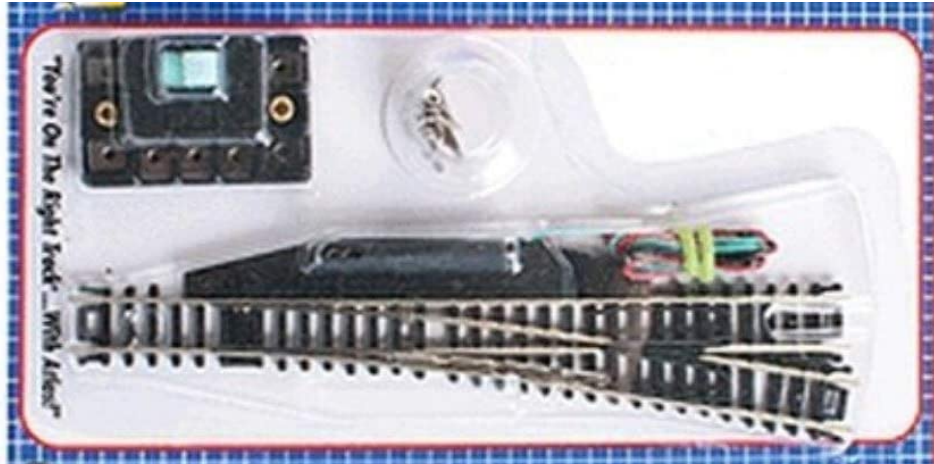


Bachmann Industries Smooth Side Coach Union Pacific N-Scale Passenger Car, 85'

6. PROJECT MATERIALS

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▶ 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

6. PROJECT MATERIALS

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▶ **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

6. PROJECT MATERIALS

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▶ 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



6. PROJECT MATERIALS

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▶ BACHMANN INDUSTRIES E Z COMMAND DCC CONTROLLER



▶ 1"X4'X8' FOAM BOARD



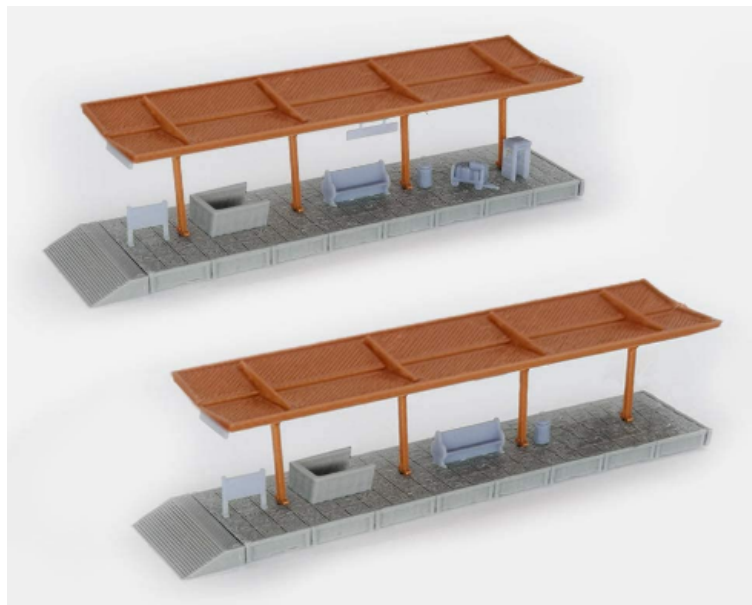
6. PROJECT MATERIALS

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



- ▶ **TRAIN STATION PASSENGER
PLATFORM**



6. PROJECT MATERIALS

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▶ MIXED MODEL TRAIN TREES



▶ PLASTIC ROCKERY TUNNEL TRACK TRAIN



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