

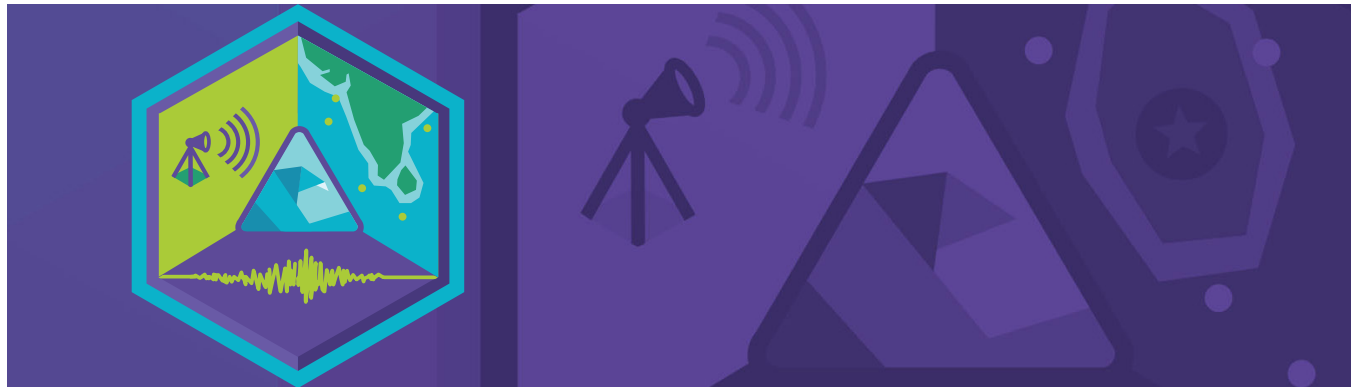


Plate Motion Engineering Internship: Tsunami Warning Systems

**Engineering Notebook
with Article Compilation**



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Plate Motion Engineering Internship: Tsunami Warning Systems

Engineering Notebook

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Name: _____ Date: _____

Plate Motion Engineering Internship: Tsunami Warning Systems **Unit Overview**

What is the best system of sensors to use in a tsunami warning system for the Indian Ocean region? How can different sensors be used to detect changes in the environment and send a signal that gives people on land enough time to move to a safer location?

In this internship, you will take on the role of a geohazards engineering intern, working to apply your knowledge of Earth's processes (like how movement at plate boundaries can result in earthquakes) to determine which earthquakes can result in tsunamis. You will learn about three sensor types—earthquake, deep water, and shallow water—and where to place them in the Indian Ocean region in order to send the people of Sri Lanka an accurate warning when a dangerous tsunami is traveling toward their shores. Your warning system must give people the greatest amount of time to move to safety, have few or no false alarms, and be low in cost.

Name: _____ Date: _____

Safety Guidelines for Science Investigations

Workplace safety is always a concern, especially in the labs here at Futura. Please review and follow these safety guidelines. If you have any questions, ask your internship coordinator for assistance.

1. **Follow instructions and listen carefully.** If you don't know what to do, ask your internship coordinator.
2. **Don't taste things.** No tasting anything or putting it near your mouth unless your internship coordinator says it is safe.
3. **Smell substances like a chemist.** When you smell a substance, don't put your nose near it. Instead, gently move the air from above the substance to your nose. This is how chemists smell substances.
4. **Protect your eyes.** Wear safety goggles if something wet could splash into your eyes, if powder or dust might get in your eyes, or if something sharp could fly into your eyes.
5. **Protect your hands.** Wear gloves if you are working with materials or chemicals that could irritate your skin.
6. **Keep your hands away from your face.** Do not touch your face, mouth, ears, eyes, or nose while working with chemicals, plants, or animals.
7. **Tell your internship coordinator if you have allergies.** We want you to be safe and comfortable at work.
8. **Be calm and careful.** Move carefully and slowly around the office and labs.
9. **Report all spills, accidents, and injuries to your internship coordinator.**
10. **Avoid anything that could cause a burn.** Ask your internship coordinator for help with hot water or hot equipment.
11. **Wash your hands with soap and water at the end of the workday, especially if you've handled plants, animals, or chemicals.**

Hana Wong, Project Director
Futura | Geohazards Engineering Division

Safety Agreement

By writing my name below, I agree to follow the rules outlined in the Safety Guidelines while working at Futura.

Name: _____ Date: _____

Day 1: Welcome to Futura!

Hello interns,

I am excited for you to join this new geohazards engineering internship at Futura! I love working for our company because we work to solve problems that affect people around the planet.

We will be working on a project for the World Ocean Administration (WOA) to design a warning system that helps people in Sri Lanka, an island nation in the Indian Ocean, get to safety in the event of a tsunami. A *tsunami* (soo-NAH-mee) is a rare, destructive ocean wave that moves a large amount of ocean water, often resulting in extreme flooding.

There are three things to consider when planning a tsunami warning system:

1. having long warning times so people can get somewhere safe;
2. avoiding false alarms, which are warnings for tsunamis that never arrive in Sri Lanka; and
3. keeping costs low, both for setup and long term maintenance.

We'll get started by understanding tsunamis. Today, your internship coordinator will introduce you to the project resources: the TsunamiAlert Design Tool and the Futura Geohazards Engineer's Dossier. Note: *Dossier* (DAW-see-ay) is a term professionals sometimes use for a set of related documents. It includes a glossary to support you if you need help with unfamiliar words. You can also find that glossary on page 33 of this Engineering Notebook.

Deliverables

- Annotations for Chapter 2: "Tsunamis: Rare but Dangerous"
- After Hours: Annotations for Chapter 1: "Request for Proposals"

I am looking forward to working with you,

Hana

Hana Wong, Project Director
Futura | Geohazards Engineering Division

Name: _____ Date: _____

After-Hours Work

Return to Message 1 on page 3 from Hana Wong and be sure you've completed all internship tasks for the day.

1. Read and annotate Chapter 1 in the Dossier: "Request for Proposals" (RFP).
2. Your internship coordinator may have asked you to complete additional tasks.
 - If you are required to read the Safety Guidelines and read and complete the Safety Agreement form, find those on page 1 of your Engineering Notebook.

Name: _____ Date: _____

Day 2: Understanding Tsunamis

Welcome back, interns!

We'll continue researching tsunamis today. Engineers often do research by reading and by building physical models. Today you will use a model to better understand how tsunamis behave. Then, you will return to the Dossier for today's reading, which is about plate boundaries and how their movements can cause tsunamis.

By understanding how tsunamis are formed, you'll be able to design a better warning system. While you are working today, think about the following focus question: *What is the relationship between plate boundaries and tsunamis?* You'll need to figure this out before you can start designing your warning system.

Deliverables

- Modeling a Tsunami Wave sheet on pages 6–7 of the Engineering Notebook
- Annotations for Chapter 3: "Plate Motion and Tsunamis"
- After Hours: Reread and revise annotations in Chapters 2 and 3, thinking about whether all earthquakes cause tsunamis.

Hope you learn a lot today!

Hana

Hana Wong, Project Director
Futura | Geohazards Engineering Division

Daily Message Notes

Name: _____ Date: _____

Modeling a Tsunami Wave

Use the tsunami tank model to compare a wind-generated wave to a tsunami wave, and learn more about how tsunamis form.

Procedure

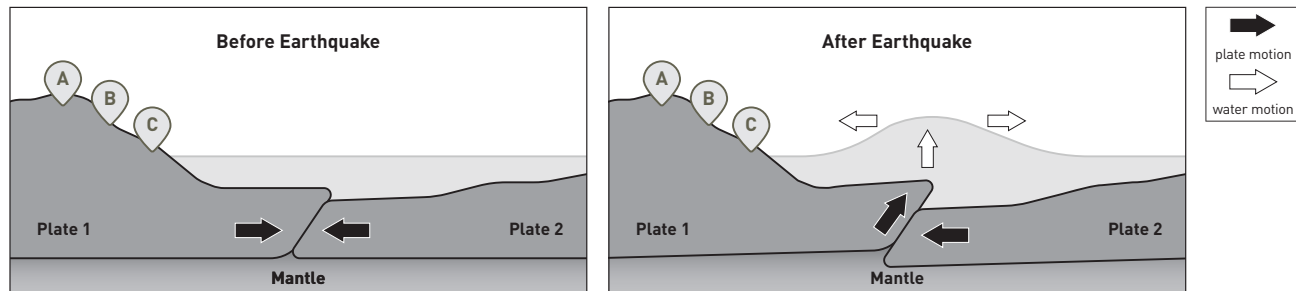
1. Set up buildings on the shore of the tsunami tank before each test.
2. Take turns testing how to generate each wave type. Record your observations.
 - a. Wind-driven wave: Use a straw to create a wind-driven wave that travels toward the shore. Do not touch the straw to the water.
 - b. Tsunami wave: Using what you have read so far about tsunamis, create a tsunami wave.
3. Complete the Conclusion questions that follow.

WAVE	WIND-DRIVEN WAVE	TSUNAMI WAVE
Caused by		
Size		
Speed		
Effects (e.g., damage)		
Additional Observations		

Name: _____ Date: _____

Modeling a Tsunami Wave (continued)

1. Which type of wave caused more damage? (circle one) **[Wind-driven / Tsunami]**. Explain why.



In the diagram above, a tsunami is caused by a(n) **[upward / downward / sideways]** shift in Plate 2. This shift is usually caused by an earthquake that occurs as Plate 1 moves **[under / above / sideways next to]** Plate 2.

2. Complete the statement above by selecting the correct responses in bold.
3. According to the tsunami tank model and the diagram above, which location (A, B, or C) will be most affected when the tsunami wave comes ashore? Why?

4. A tsunami can form when there is a shift in the seafloor. How do the parts of the tsunami tank model relate to the diagram above?

5. List one or more things you learned from the tsunami tank model that can help you design your tsunami warning system.

Name: _____ Date: _____

After-Hours Work

Return to Message 2 on page 5 from Hana Wong and be sure you've completed all internship tasks for the day.

- Read Chapter 2 in the Dossier: "Tsunamis: Rare but Dangerous" and Chapter 3: "Plate Motion and Tsunamis."
- Add to or revise your annotations using this focus question:
Do all earthquakes cause tsunamis?
- Your internship coordinator may have asked you to complete additional tasks. Double-check the Daily Message and Daily Message Notes to see if there are other deliverables that need to be completed after hours.

Name: _____ Date: _____

Day 3: Plate Boundary Types

Greetings, interns!

This tsunami warning project is very important to me because I have close friends who were affected by the large tsunami that struck Japan after an extreme earthquake in 2011. My friends were able to get to safety in time because of Japan's warning system.

You learned previously that Earth is made of giant plates that move and that tsunamis are caused by vertical shifts in the seafloor due mostly to earthquakes under the water.

Today, I want you to work on understanding which locations in the Indian Ocean region are most likely to have earthquakes that would cause tsunamis. You will use the Dossier and the TsunamiAlert Design Tool. You'll be working on this research with your fellow interns, so I want you to practice communicating scientifically so everyone understands this region clearly. This research will help you when planning your tsunami warning system for Sri Lanka.

Deliverables

- Annotated Map of the Indian Ocean Region

Research carefully!

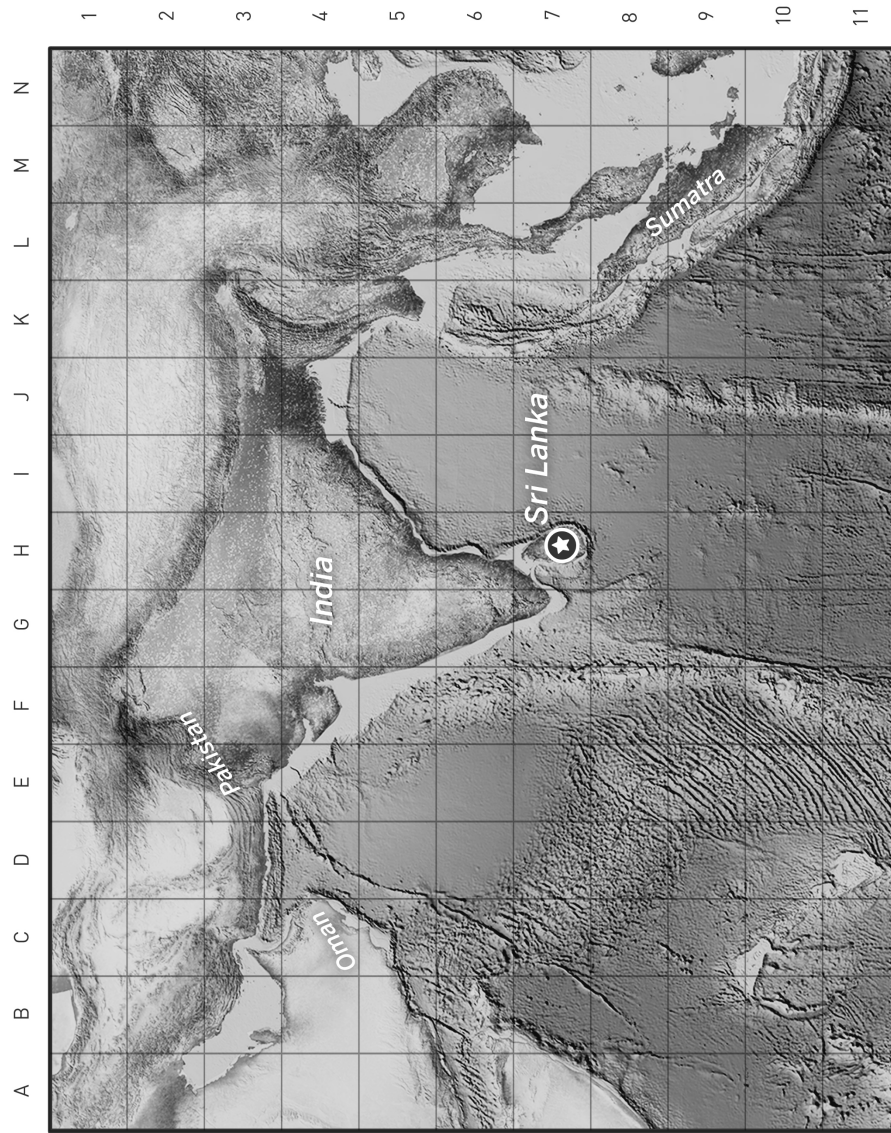
Hana

Hana Wong, Project Director
Futura | Geohazards Engineering Division

Daily Message Notes

Name: _____ Date: _____

Map of the Indian Ocean Region



KEY

PLATE BOUNDARY TYPE

- Convergent
- Divergent
- Transform

EARTHQUAKE

- Earthquake
- ◐ Earthquake that caused a local tsunami
- Earthquake that caused an ocean-wide tsunami

Name: _____ Date: _____

Day 4: Tsunami Warning Systems

Hi Interns!

At Futura, collaboration is important. We work in small teams to share information and to solve challenging problems. I heard you worked well with your colleagues to communicate scientifically about the patterns and evidence needed to understand the Indian Ocean region. Please continue to practice this skill throughout the rest of the internship!

Today, you will complete the Research phase by reading Chapter 4: “Tsunami Warning Systems” from the Dossier and analyzing the sensor types. You will also do some focused exploration of how the sensors in TsunamiAlert work together. For after-hours work, I want you to describe your understanding of the project so far by submitting the Project Summary.

Deliverables

- Annotations for Chapter 4: “Tsunami Warning Systems”
- Sensor Analysis
- After Hours: Project Summary

Warm regards,

Hana

Hana Wong, Project Director
Futura | Geohazards Engineering Division

Daily Message Notes

Name: _____ Date: _____

Sensor Analysis

SENSOR TYPE	BEST FOR DETECTING	PLACED ON OR IN	PROS	CONS
Earthquake	☐ Earthquakes	☐ Land		
	☐ Tsunamis, local	☐ Water, deep		
	☐ Tsunamis, ocean-wide	☐ Water, shallow		
Shallow	☐ Earthquakes	☐ Land		
	☐ Tsunamis, local	☐ Water, deep		
	☐ Tsunamis, ocean-wide	☐ Water, shallow		
Deep	☐ Earthquakes	☐ Land		
	☐ Tsunamis, local	☐ Water, deep		
	☐ Tsunamis, ocean-wide	☐ Water, shallow		

Name: _____ Date: _____

After-Hours Work

Return to Message 4 on page 11 from Hana Wong and be sure you've completed all internship tasks for the day.

- Complete the Project Summary form on the next page. If needed, refer back to the RFP in the Dossier to review the project details.
- Your internship coordinator may have asked you to complete additional tasks. Double-check the Daily Message and Daily Message Notes to see if there are other deliverables that need to be completed after hours.

Name: _____ Date: _____

Project Summary

Defining the Problem: Summarize your understanding of the project by answering the following questions. You may wish to review the Dossier to help you respond to the questions.

1. What is the engineering problem you are trying to solve?

2. Describe the first criterion—maximize average warning time—and why it is important.

3. Describe the second criterion—minimize false alarms—and why it is important.

4. Describe the third criterion—keep costs low—and why it is important.

5. Based on your research so far, which criterion do you think is most important for a successful tsunami warning system design? Why?

Name: _____ Date: _____

Day 5: Designing Warning Systems

Hello interns!

Today you begin the Design phase of the internship. Think about what you've learned from reading the Dossier during the Research phase: the different plate boundary types, the earthquake conditions that cause tsunamis, and where in the Indian Ocean region those earthquakes might happen. You will use TsunamiAlert to build warning systems that will give people as much time as possible to get to safety, without having too many false alarms or costing too much.

You'll run many iterative tests to find an effective design. Each time you test a warning system design, you will analyze the results to see how you can improve your next version. When engineers test designs, they use the results to help plan the next design.

Before you leave today, your team should send me the results of the design you like best. I'll review it and send you feedback about how well your design addresses the project criteria.

Deliverables

- Several designs recorded on TsunamiAlert Data
- TsunamiAlert Design form

Cheers,

Hana

Hana Wong, Project Director
Futura | Geohazards Engineering Division

Daily Message Notes

Name: _____ Date: _____

TsunamiAlert Design

Record your best design here. Then you will submit your best design in the TsunamiAlert Design form in Futura Workspace in order to receive feedback from the project director. Note: Only one partner needs to submit a form for feedback.

Design Details

Version: _____

Earthquake Sensors Quantity: _____

Earthquake Sensors Coordinates:

Shallow Sensors Quantity: _____

Shallow Sensors Coordinates:

Name: _____ Date: _____

TsunamiAlert Design (continued)

Deep Sensors Quantity: _____

Deep Sensors Coordinates:

Earthquake Mode (circle one): Random Fixed

Test Results

Average Warning Time (minutes): _____

All necessary warnings received? (circle one): Yes No

False alarms: _____

Total 50-Year Cost (\$): _____

Name: _____ Date: _____

Day 6: Optimal Designs

Hi interns,

I reviewed the results for the design your team submitted and sent a feedback letter. Work with your colleagues and internship coordinator to review and interpret my comments. Then, think about my suggestions as you do more iterative testing and choose an optimal tsunami warning system design. It may be helpful to revisit the Dossier as you plan your final designs. After hours, I want to know your thoughts about the trade-offs of your optimal design.

You've probably noticed that each version you've designed has trade-offs—when a design can be strong for one criterion, but not as good for another. To identify an optimal solution to a problem, engineers share and discuss results, consider trade-offs, and set priorities in order to improve their designs.

Deliverables

- Design Feedback Summary
- Record several new designs
- Optimal design selected
- After-Hours: Trade-Offs Reflection

Cheers,

Hana

Hana Wong, Project Director
Futura | Geohazards Engineering Division

Daily Message Notes

Name: _____ Date: _____

Design Feedback Summary

	AVERAGE WARNING TIME	FALSE ALARMS	TOTAL 50-YEAR COST (\$)
Submitted Version Test Results			
Feedback from project director			
Goal			
Redesign Strategy			

Name: _____ Date: _____

After-Hours Work

Return to Message 6 on page 16 from Hana Wong and be sure you've completed all internship tasks for the day.

- Complete the Trade-Offs Reflection form on the next page.
- Your internship coordinator may have asked you to complete additional tasks. Double-check the Daily Message and Daily Message Notes to see if there are other deliverables that need to be completed after hours.

Name: _____ Date: _____

Trade-Offs Reflection

A *trade-off* happens in a situation where a design has good results for one criterion but not for another. Look at your optimal tsunami warning system design. Describe some of the trade-offs you noticed while designing your warning system.

1. Which criterion did you prioritize? (check one)

- ☐ maximize average warning time
- ☐ minimize false alarms
- ☐ keep costs low

2. Why did you prioritize this criterion?

3. When you prioritized this criterion, what were some of the trade-offs? Describe what happened to the results of the other two criteria.

Name: _____ Date: _____

Day 7: Outlining Decisions

Hello interns,

Today you will start working on your design proposal. Proposals are another way scientists and engineers communicate their ideas. You should have selected a design that you believe is optimal; you will use the proposal to explain why you think so! Writing good proposals can be hard, so I've asked your internship coordinator to help you outline the most important section, the Design Decisions. You might also want to refer to the Dossier for information and resources to help you.

Engineering proposals explain how a design addresses each of the project criteria. If you include strong evidence in your argument that demonstrates you understand how and why your design works, it is more likely that your proposal will be considered by World Ocean Administration. The outline process will help you collect and organize evidence that supports the argument that you have selected an optimal design. I will review the Background Research sections of your outline and send feedback to help improve your final proposals. I always appreciate feedback when I am working on a formal proposal!

Deliverables

- Proposal Outline

Use lots of evidence!

Hana

Hana Wong, Project Director
Futura | Geohazards Engineering Division

Daily Message Notes

Name: _____ Date: _____

Proposal Outline

Instructions

For this outline, you need to list important information for the Design Decisions for each criterion. Refer to your TsunamiAlert Data and the Dossier.

Optimal Design

List the design details of your proposed optimal design.

Version #: _____

	BUILD Design Details		
Sensor Type & Quantity	☐ Earthquake	☐ Shallow	☐ Deep
Coordinates (*placed on land)			
Earthquake Mode:	☐ Random	☐ Fixed	

Design Decisions

For each criterion, list the pieces of evidence from your data analysis and background research that support your optimal design.

Average Warning Time

DATA ANALYSIS	
Final result (minutes):	Design goal (minutes):
All necessary warnings received? ☐ Yes ☐ No	
Comparison to another design:	
BACKGROUND RESEARCH	
Think about how your design choices affected warning time. What information about sensor types and placement affected the warning time for each ocean-wide tsunami?	

Name: _____ Date: _____

Proposal Outline (continued)

False Alarms

DATA ANALYSIS

Final result:

Design goal:

Comparison to another design:

BACKGROUND RESEARCH

Think about how your design choices affected false alarms. What information about earthquakes, sensor types, and sensor placement affected the number of false alarms?

Total 50-Year Cost

DATA ANALYSIS

Final result (\$):

Design goal (\$):

Comparison to another design:

BACKGROUND RESEARCH

Think about how your design choices affected the 50-year cost. What information about sensor types and placement affected the cost?

Name: _____ Date: _____

Day 8: Writing Design Decisions

Greetings interns,

Today you will use my feedback on your proposal outlines to write the Design Decisions paragraphs of your proposal. These paragraphs are the heart of your argument that explains why your tsunami warning system design is an optimal one. You might also want to refer to the Dossier for information and resources to help you write.

Writing strong proposals for a specific audience, helping them understand the project and your decisions, is an important part of being an engineer. You know more about the science behind your design than most of the people who will be reading your proposal, so your writing should be clear and professional. Writing clear arguments that explain your thinking is an essential part of scientific communication.

Deliverables

- Final Proposal: Design Decision paragraphs

Write carefully,

Hana

Hana Wong, Project Director
Futura | Geohazards Engineering Division

Daily Message Notes

Name: _____ Date: _____

Tips: Help With Your Proposal

Interns,

If you need some help getting started with your paragraphs for the Final Proposal on page 25, here are some ideas to choose from.

Design Decisions Paragraphs

About specific criteria:

- For our proposed design, the average warning time was . . .
- We were able to minimize false alarms by . . .
- We were able to keep costs low by . . .
- Using the Futura TsunamiAlert Design Tool, we picked a design that . . .

When talking about your goals:

- Our goal was . . .
- Based on design feedback, we chose to set a goal to . . .

For comparing designs:

- In another design, we got _____ but . . .

For talking about background research:

- Background research told us that . . .
- In the Dossier, we learned that . . .
- Research with TsunamiAlert showed us that . . .

Introduction

- This tsunami warning system design used *(list sensor types and locations)*.
- The results showed the average warning time was _____.
- This design had _____ false alarms.
- The total 50-year cost was _____.

Conclusion

- Our tsunami warning system design is the optimal choice because . . .
- Our priority was the criterion _____ because . . .
- Our tsunami warning system design will meet the needs of World Ocean Administration because . . .
- Even though our design does not _____ we think it is optimal because . . .
- This tsunami warning system design will *(write something about one criterion here)* well because . . .
- A trade-off we had to make in our optimal design was . . .

Hana Wong, Project Director
Futura | Geohazards Engineering Division

Name: _____ Date: _____

Final Proposal

When writing your Final Proposal, remember to write in a clear and professional manner. Refer to these resources:

- Proposal Rubric and Sample Proposal
- TsunamiAlert Data
- Geohazards Engineer's Dossier
- Proposal Outline feedback letter

Introduction

Use your responses from the Project Summary to describe the project goal and criteria. Add one to two sentences to describe your optimal design.

[illegible]

Name: _____ Date: _____

Final Proposal (continued)

Design Decisions

Use your Proposal Outline and feedback from your project director to explain how your design addresses each criterion.

Average Warning Time

[illegible]

False Alarms

Name: _____ Date: _____

Final Proposal (continued)

Total 50-Year Cost

[illegible]

Name: _____ Date: _____

Final Proposal (continued)

Conclusion: Considering Trade-Offs

Use your responses from the Trade-Offs Reflection to describe your design priority and the resulting trade-offs. Add your closing statement.

Name: _____ Date: _____

Day 9: Finishing Your Proposal

Hello interns,

Today you'll be focusing on finishing your proposal by adding two more paragraphs: the beginning and the ending! Your internship coordinator will help you use the Project Summary to write the Introduction and the Trade-Offs Reflection to write the Conclusion. You might also want to refer to the Dossier for information and resources to help you write.

These two paragraphs are the final sections of your proposal. The introduction explains the project to the reader, while the conclusion shows that you've thought carefully about the trade-offs involved in your optimal tsunami warning system design. Remember to use scientific and professional language to communicate your ideas.

You might notice that writing this proposal is like iterative testing—you are taking a version, analyzing and revising it, and then rewriting to improve the final version!

Deliverables

- Completed Final Proposal

I look forward to reading your excellent proposals!

Hana

Hana Wong, Project Director
Futura | Geohazards Engineering Division

Daily Message Notes

Name: _____ Date: _____

Day 10: Great Job, Interns!

Dear interns,

Today is the final day of your internship with me here at Futura's Geohazards Engineering Division. I'm impressed with the variety of tsunami warning systems you've designed. I really enjoyed watching you learn how to think critically about earthquakes, tsunamis, and sensor types, while practicing good scientific communication with your colleagues. I hope that you will be able to take some of what you have learned here and apply it to help you with future problem solving and scientific arguments. You've been great interns!

There is one last task that I have for you: an Internship Exit Survey. Please get started on it now—your responses will help us improve internships for the next batch of interns!

Deliverables

- Internship Exit Survey

Good luck in the future!

Hana

Hana Wong, Project Director
Futura | Geohazards Engineering Division

Daily Message Notes

Name: _____ Date: _____

Internship Exit Survey

Futura would like to improve the internship experience for future interns. Please complete this survey to give us feedback.

How comfortable would you feel explaining the following concepts to a new intern?

1. How a student's job is different from an intern's job. (check one)

- ☐ Very uncomfortable. I don't understand this.
- ☐ Uncomfortable. I'm not sure I understand this.
- ☐ Pretty comfortable. I think I understand this.
- ☐ Very comfortable. I totally understand this.

2. What criteria are and how they are related to designing something. (check one)

- ☐ Very uncomfortable. I don't understand this.
- ☐ Uncomfortable. I'm not sure I understand this.
- ☐ Pretty comfortable. I think I understand this.
- ☐ Very comfortable. I totally understand this.

3. What a trade-off is and how a trade-off affects engineering designs. (check one)

- ☐ Very uncomfortable. I don't understand this.
- ☐ Uncomfortable. I'm not sure I understand this.
- ☐ Pretty comfortable. I think I understand this.
- ☐ Very comfortable. I totally understand this.

4. Why scientific communication is important in engineering. (check one)

- ☐ Very uncomfortable. I don't understand this.
- ☐ Uncomfortable. I'm not sure I understand this.
- ☐ Pretty comfortable. I think I understand this.
- ☐ Very comfortable. I totally understand this.

Name: _____ Date: _____

Internship Exit Survey (continued)

Imagine you are giving advice to a new Futura Engineering intern.

5. What would you tell them about the engineering design process?

6. What was hard or challenging about the internship?

7. What tips would you suggest for a successful internship?

Plate Motion Engineering Internship Glossary

analyze: to examine in detail for a purpose

analizar: examinar en detalle y con un propósito

argument: a claim supported by evidence

argumento: una afirmación respaldada por evidencia

convergent: moving toward the same place

convergente: que se mueven hacia el mismo lugar

criteria: standards by which something may be judged

criterios: normas por medio de las cuales se puede juzgar algo

deliverable: a thing to be delivered, usually in a development or design process

entregable: una cosa que debe entregarse, usualmente durante un proceso de desarrollo o diseño

divergent: moving apart in different directions

divergente: que se mueven y se separan en diferentes direcciones

dossier: a set of related documents about a particular topic

expediente: un conjunto de documentos relacionados sobre un tema particular

earthquake: a sudden shaking of Earth's surface

terremoto: una sacudida repentina de la superficie de la Tierra

engineer: a person who uses math and science to design things

ingeniero/a: una persona que utiliza las matemáticas y la ciencia para diseñar cosas

evacuate: to move somewhere safe

evacuar: moverse a un lugar seguro

evidence: information about the natural world that is used to support or go against (refute) a claim

evidencia: información sobre el mundo natural que se utiliza para respaldar o rechazar (refutar) una afirmación

Plate Motion Engineering Internship Glossary (continued)

false alarm: a warning that is generated for a specific area, even though no emergency or disaster occurs in that area

falsa alarma: una advertencia que se genera para un área específica, aunque no ocurre ninguna emergencia o desastre en esa área

geohazard: a natural disaster on Earth, such as an earthquake, tornado, or flood

peligro geológico: un desastre natural que ocurre en la Tierra, como un terremoto, tornado o inundación

geohazards engineer: an engineer who applies concepts from earth science and physics to help minimize the impact of natural disasters

ingeniero/a de georriesgos: un/a ingeniero/a que aplica conceptos de geociencias y de física para ayudar a minimizar el impacto de los desastres naturales

interns: beginners at a workplace who do work that is closely supervised because they are learning on the job

becarios: principiantes que hacen un trabajo estrechamente supervisado porque están aprendiendo durante el mismo

internship coordinator: the person who supervises interns during a project

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iterative testing: repeating a process in a way that considers the results of a previous design

pruebas iterativas: la repetición de un proceso de manera que se consideren los resultados de un diseño anterior

landform: a feature that forms on the surface of a planet, such as a mountain, channel, or sand dune

accidente geográfico: un rasgo que se forma sobre la superficie de un planeta, como una montaña, un canal o una duna de arena

magnitude: the size or strength of something, such as an earthquake or tsunami

magnitud: el tamaño o la fuerza de algo, como un terremoto o un tsunami

mid-ocean ridge: an underwater mountain range formed when two plates move apart

cordillera oceánica: una cadena montañosa submarina que se forma cuando se separan dos placas

Plate Motion Engineering Internship Glossary (continued)

model: an object, diagram, or computer program that helps us understand something by making it simpler or easier to see

modelo: un objeto, diagrama o programa de computadora que nos ayuda a entender algo haciéndolo más simple o fácil de ver

optimal: most successful, considering the situation

óptimo: más exitoso, considerando la situación

pattern: something we observe to be similar over and over again

patrón: algo que observamos que sea similar una y otra vez

plate: one of the very large sections of hard, solid rock that make up Earth's outer layer

placa: una de las muy grandes secciones de roca dura y sólida que forman la capa externa de la Tierra

plate boundary: the place where two plates meet

límite de placas: el lugar donde se juntan dos placas

project director: the person who is responsible for making sure a project's goals are addressed

director/a de proyecto: la persona responsable de asegurarse de que se cumplan las metas de un proyecto

proposal: a formal design that is supported by evidence, and submitted for discussion and review

propuesta: un diseño formal respaldado por evidencia y presentado para discusión y revisión

request for proposals: a document asking engineers to submit a well-supported, formal design describing how they would solve a problem

solicitud de propuestas: un documento para pedir a los/as ingenieros/as que presenten un diseño formal, bien sustentado, que describa cómo resolverían un problema

scientific communication: the process of sharing scientific arguments, explanations, ideas, or data with an audience

comunicación científica: el proceso de compartir argumentos, explicaciones, ideas o datos científicos con un público

sensor: a device that detects information in its environment and responds

sensor: un aparato que detecta información en su ambiente y responde

Plate Motion Engineering Internship Glossary (continued)

subduction: the process by which rock material moves under Earth's outer layer and into the mantle due to plate motion

subducción: el proceso por medio del cual el material rocoso se mueve bajo la capa externa de la Tierra y hacia dentro del manto debido al movimiento de las placas

trade-off: when you have to give up one thing in return for another

concesión: una situación en la que se debe renunciar a algo para obtener otra cosa a cambio

transform boundary: a plate boundary where two plates move sideways past each other

límite transformante: un límite de placas donde dos placas se pasan de largo una a otra en dirección horizontal

trench: a long, deep indentation in the ocean floor formed when two plates move together

fosa: una hendidura larga y profunda en el piso oceánico que se forma cuando dos placas se juntan

tsunami: a large ocean wave caused by a sudden shift in the seafloor

tsunami: una gran onda oceánica causada por un cambio repentino en el piso oceánico

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Plate Motion Engineering Internship: Tsunami Warning Systems

Article Compilation



FUTURA GEOHAZARDS ENGINEER'S DOSSIER



FUTURA
MECHANICAL ENGINEERING

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Chapter 1:

Request for Proposals (RFP)

In 2004, an earthquake near the Indonesian island of Sumatra caused the deadliest natural disaster in modern human history—a powerful ocean wave, called a tsunami (soo-NAH-mee), that devastated countries around the Indian Ocean. Tsunamis are rare natural disasters that can result in great loss of life and property. The countries of Indonesia, Sri Lanka, Thailand, and India were hit the hardest by the powerful waves. More than 230,000 people were killed and over a million people lost their homes. At the time, there was no tsunami warning system in that region. It's not possible to prevent a tsunami, but people may be able to get to safety if they are warned about an approaching tsunami in time.

The countries around the Indian Ocean installed a tsunami warning system after the 2004 disaster. Today people are exploring ways to improve that warning system. The World Ocean Administration (WOA) is seeking proposals for an improved tsunami warning system for the Indian Ocean region. Futura's Geohazards Division will focus their proposals on providing warnings for the country of Sri Lanka.



When this tsunami occurred in the Indian Ocean in 2004, people nearby were not aware that a tsunami was approaching. If there had been a tsunami warning system in place, these people could have evacuated to safety.

Successful proposals will address three criteria:

1. Maximize average warning time

When a tsunami occurs, people in coastal areas need to evacuate and move to higher ground. The sooner people receive the warning that a tsunami is coming, the more time they have to evacuate and get somewhere safe.

2. Minimize false alarms

Warning systems must be accurate. False alarms occur when warning systems send tsunami warnings to specific areas, but no tsunami reaches those areas. Telling people to evacuate when no tsunami occurs can cost millions of dollars. If false alarms happen more than once, people may become less likely to believe the warning system, and they may not respond to the next tsunami warning.

3. Keep costs low

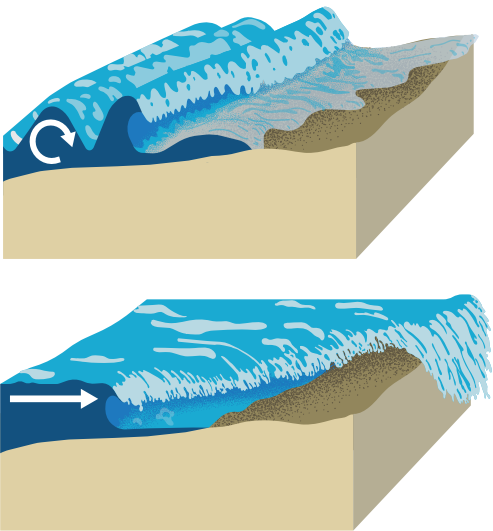
The cost of a tsunami warning system includes both the cost to install the system and the cost to maintain the system over many years. The cost will be shared by WOA and the many countries in the Indian Ocean region. Countries also have to budget for other things like schools, roads, bridges, and other government services, so the 50-year cost of the warning system should be as low as possible.



Many coastal regions that are at risk for tsunamis post signs telling people what to do in the event of an earthquake that could cause a tsunami.

Tsunamis: Rare But Dangerous

A tsunami is a large, destructive ocean wave caused by a sudden shift in the seafloor. These shifts are usually due to underwater earthquakes, but underwater landslides, volcanic eruptions, or meteor strikes can also cause tsunamis. Most tsunamis do not result in the kinds of waves you might see surfers riding, which are caused by wind at the ocean’s surface. Instead, tsunamis look more like a fast-rising tide or a flood. Tsunami waves travel much faster and are much longer and much taller than regular wind-driven ocean waves. Wind-driven waves occur just at the surface of the water. In contrast, a tsunami wave affects all of the water in the area where the seafloor shift occurred, from the bottom of the ocean all the way up to the surface. In deep water, tsunami waves are long but not very tall—a tsunami wave can pass under a ship without people on board even noticing. As tsunami waves approach the shore, they slow down and increase in height.



Tsunamis are different from waves that are driven by wind. One of the main things that makes tsunamis so much more dangerous than wind-driven waves is a tsunami’s ability to quickly flood the land, causing a lot of damage and destruction.

	Speed	Wavelength	Wave Height at Shore
TSUNAMI WAVE	Up to 800 km/hr (about 500 mi/hr or the speed of a flying jet)	100 km (62 mi) or greater	Up to 30 m (about 100 ft) vertical height at shore
OCEAN WAVE	Up to 90 km/hr (55 mi/hr or the speed of a car on the highway)	Less than 120 m (about 400 ft)	Average 3 m (10 ft) vertical height

Figure 1

Sea surface

Sea floor

Plates

The seafloor around a convergent boundary before any shifting of plates

Figure 2

One plate subducts—moves under the other—which causes a mass of water to move upward.

Figure 3

The mass of water begins to move outward.

Figure 4

The tsunami wave peaks increase in height as they reach a shallow area near the shore.

When a tsunami does occur, the wave travels in all directions from the source. The first peak of a tsunami wave may not be the most damaging part of the wave when it arrives on shore—later peaks may be larger and more dangerous. The tsunami can flood the land over the course of several hours: multiple wave peaks come ashore, washing away buildings, cars, trees, wildlife, and people. The amount of damage a tsunami can cause depends on the strength and location of the earthquake or other event that caused the tsunami. The geologic events that cause tsunamis cannot be predicted. However, once certain earthquakes and additional data indicate a tsunami, tsunami warnings can give many people time to evacuate to safety before a tsunami hits.



A tsunami struck Kesennuma, Japan, in March of 2011, causing great destruction in the coastal city.

Chapter 3:

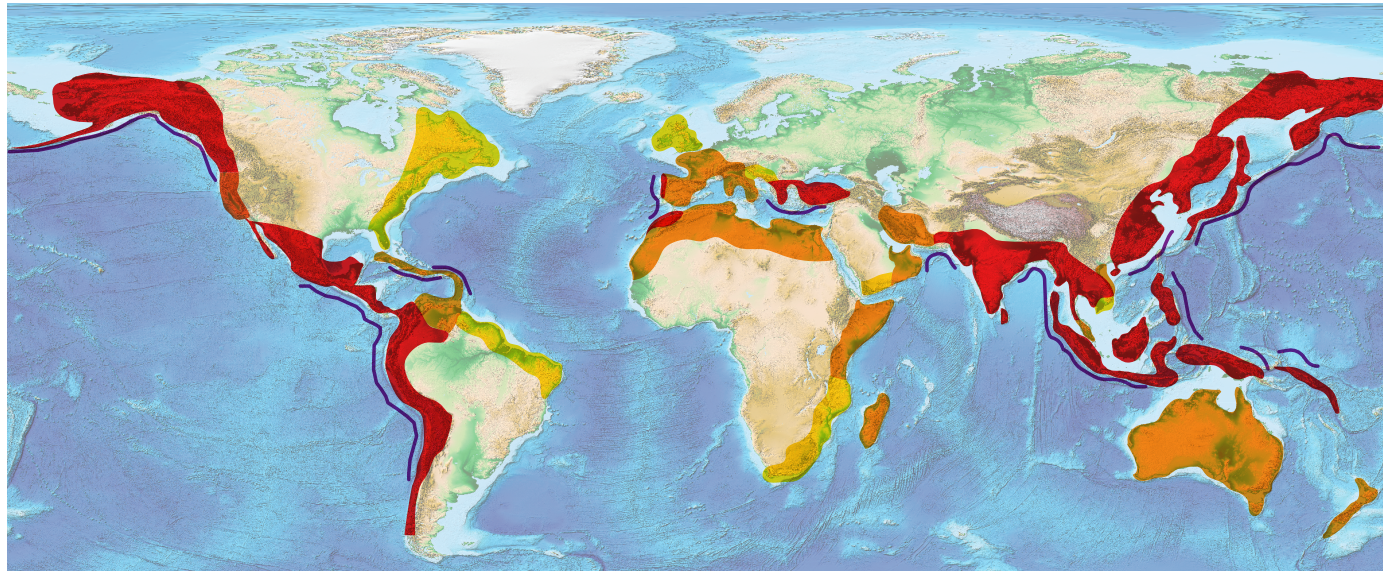
Plate Motion and Tsunamis

Imagine you are at the beach on a warm summer day, and you suddenly feel the ground shake beneath you! Should you worry about a tsunami? It's important to know that not all earthquakes cause tsunamis—the magnitude and location of the earthquake and the type of plate boundary involved all affect whether a tsunami will occur.

Tsunamis are most often caused by earthquakes, but not just any earthquakes. The earthquake must occur under or very near the ocean. Earthquakes that are centered inland don't cause tsunamis. Also, only very strong earthquakes can cause tsunamis. Most earthquakes have a magnitude below 2.5—too small to be felt by people at all. Earthquakes that are magnitude 6.5 or higher cause very strong shaking and can make it hard for people to stay standing. An earthquake under the ocean must be even bigger than that—it must have a magnitude larger than 7.0 to release the energy required to cause a tsunami.

Earth's surface is made of huge plates that move slowly over time. The places where these plates meet are called plate boundaries. Sudden movement at some types of plate boundaries can generate earthquakes. The type of plate boundary where an earthquake happens partly determines whether that particular earthquake will cause a tsunami.

Tsunami Threat

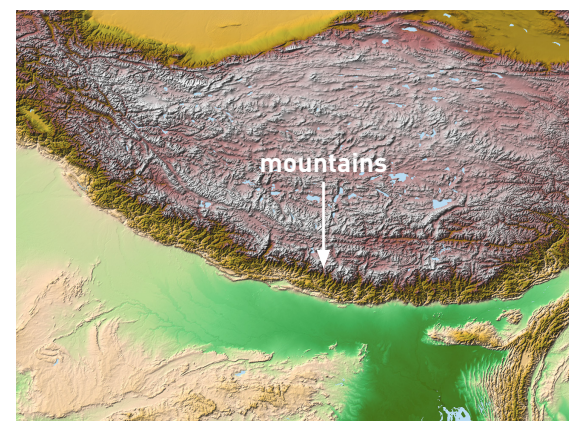
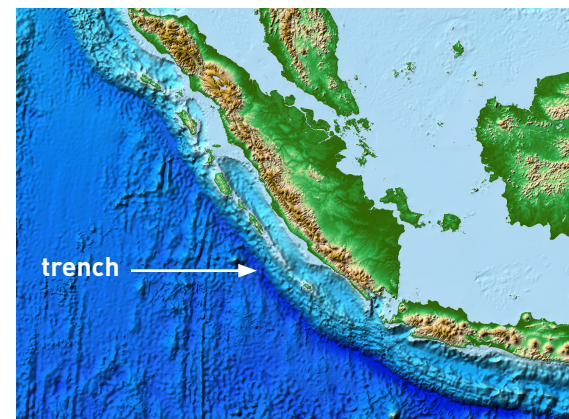
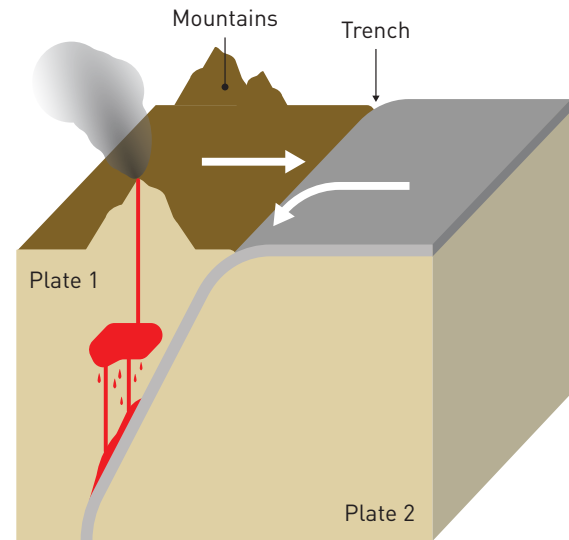


- High probability of underwater earthquakes
- High risk of tsunamis
- Medium risk of tsunamis
- Low risk of tsunamis

In the event of an earthquake on the seafloor, tsunamis are more likely to hit some coastal areas than others. The areas of highest risk are shown in red.

CONVERGENT PLATE BOUNDARIES

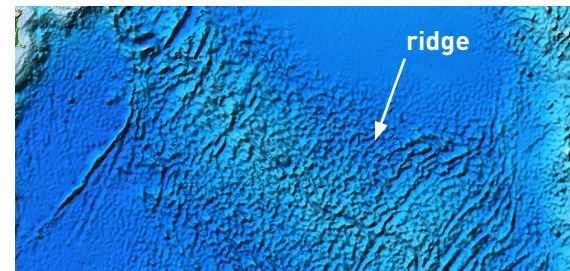
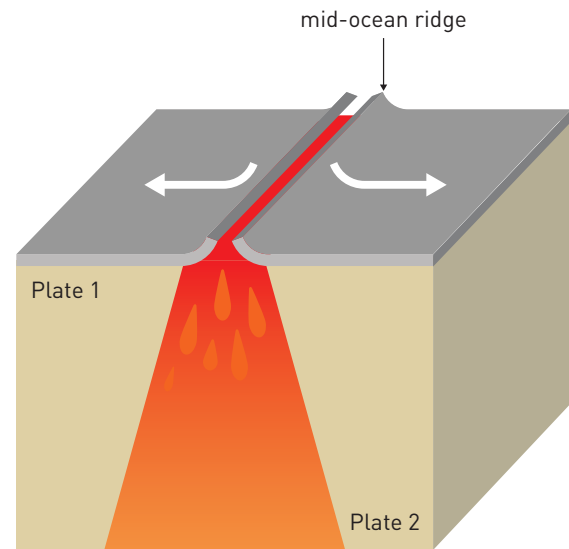
Convergent plate boundaries occur where two plates are moving toward each other. Often at a convergent plate boundary, one plate will move under the other. This is called subduction. Convergent boundaries often cause mountain ranges to form, which we typically see on land. On the seafloor, convergent boundaries result in landforms known as ocean trenches, where seafloor is destroyed as one plate moves under the other. As subduction occurs, pressure builds up between the plates. A large earthquake can release this built-up pressure, resulting in a quick vertical movement of the plate. In the ocean, this type of plate movement also shifts the water above the seafloor upward, which can cause a tsunami.



Large earthquakes occur most frequently at convergent (or subducting) plate boundaries, where a dense plate is moving under a less dense plate.

DIVERGENT PLATE BOUNDARIES

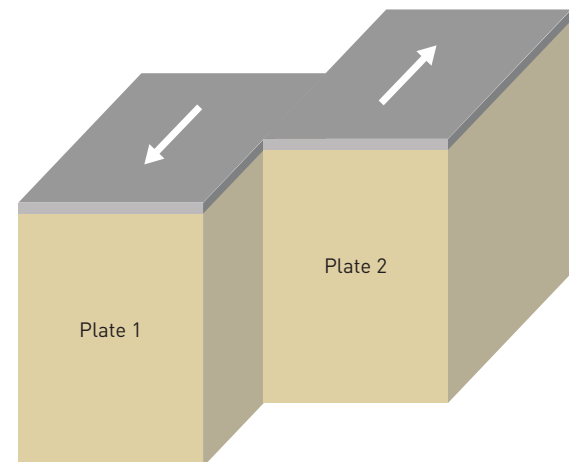
Divergent plate boundaries occur where two plates are moving away from each other. Under the ocean, the result is usually the formation of new seafloor, which causes landforms known as mid-ocean ridges. While there can be earthquakes at divergent plate boundaries, they are typically not strong enough, and do not generate enough vertical shift in the seafloor, to cause a tsunami.



Earthquakes that take place at divergent (or spreading) boundaries are usually not strong enough to cause tsunamis.

TRANSFORM PLATE BOUNDARIES

Transform plate boundaries occur where two plates are moving sideways past each other. There are no major landforms at transform boundaries, but there are many earthquakes. While it's possible to generate a tsunami at this type of plate boundary, the earthquakes from this plate movement are unlikely to cause tsunamis because plates moving horizontally do not typically raise or lower the seafloor—or the water above it.



Earthquakes that take place on transform boundaries, where two plates slide past each other, are unlikely to cause tsunamis because they do not raise or lower the seafloor very much.

Chapter 4:

Tsunami Warning Systems

Tsunamis can be local or ocean-wide. A local tsunami wave only reaches the shores closest to the earthquake that caused it. An ocean-wide tsunami wave travels to locations across the ocean. When people living near the ocean feel a strong earthquake, they may move inland to safety just in case there's a tsunami. However, people living on the other side of the ocean feel no shaking and don't know a tsunami wave may be moving towards them. This is why tsunami warning systems are important, especially for ocean-wide tsunamis.

Tsunami warning centers evaluate whether or not to issue warnings to different locations after a geologic event. These systems use data collected from sensors that measure earthquakes and changes in the ocean. When the sensors detect changes in their environment, they send data to computers. Scientists interpret the data, considering how much data they've received and from which types of sensors, and send evacuation warnings to locations likely to be affected.

Sensors: Data Reliability and Cost

Tsunami systems use a variety of types of sensors. Some types of sensors send data that is more reliable than others for issuing a tsunami warning. If scientists receive information from a type of sensor that sends reliable data, they might only need data from one other sensor to issue a tsunami warning. However, if the information is coming from a type of sensor that sends less reliable data, the scientists might wait for data from additional sensors before issuing a tsunami warning.

The costs of a warning system depend on the type and number of sensors used. Costs include buying and installing sensors, maintaining them, and replacing them when they break. Sensors can break during normal use, but can also break if they are too close to an earthquake.

Different combinations of sensors can cause false alarm warnings for a particular location—for example, when a local tsunami wave doesn't reach that location or when a strong earthquake doesn't cause a tsunami.

Sensor Types

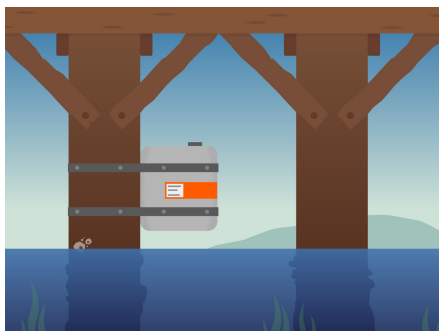
Futura will consider three types of sensors for this project.



Earthquake sensors can be installed on the seafloor or on land.

EARTHQUAKE SENSOR

Earthquake sensors measure Earth's shaking. They are good at detecting earthquake activity within a certain distance, but cannot detect tsunamis. Scientists can use earthquake location and magnitude when deciding whether to issue a tsunami warning. Earthquake sensors can be placed anywhere on land or on the seafloor, in water of any depth. Some earthquakes can cause these sensors to send false alarms.



Shallow ocean sensors are often placed in shallow water near the shore or attached to a pier.

SHALLOW SENSOR

Shallow sensors measure changes in ocean surface levels. These sensors do not detect earthquake activity, but are good indicators of approaching tsunami waves. They can be placed in shallow water near the shore or attached to a pier. If a shallow sensor sends data for a small, local tsunami, it can lead to a false alarm for locations that aren't at risk.



Deep sensors are installed on the bottom of the ocean in deep water.

DEEP SENSOR

Deep sensors measure changes in ocean water pressure that occur as a tsunami wave passes over them. They do not detect earthquake activity, but are excellent tsunami indicators. These sensors must be placed on the seafloor in deep water. Like shallow sensors, deep sensors sending data for a local tsunami can lead to a false alarm for faraway locations not at risk. These sensors may also send false data if a nearby earthquake causes a pressure change without actually leading to a tsunami.

Summary of Sensor Characteristics

Futura will consider three types of sensors for this project.

EARTHQUAKE SENSOR	SHALLOW SENSOR	DEEP SENSOR
Data reliability low	Data reliability medium	Data reliability high
Data sent very short delay	Data sent long delay	Data sent short delay
Cost used on land: \$\$ used on seafloor: \$\$\$\$	Cost \$	Cost \$\$\$\$\$
Frequency of breaks rare	Frequency of breaks occasional	Frequency of breaks often

Proposal Resources

Sample Proposal: Designing a Greener Toothbrush

INTRODUCTION

Our team at Futura Engineering is working for Dentists for the Planet to design a better toothbrush that isn't bad for the Earth but is also good for people's teeth. The toothbrush should have a low environmental impact so it doesn't make trash or pollution when you're done with it. Designs should have a high clean-mouth rating because that means the toothbrush removes as much tooth plaque as possible. And the toothbrush should be low-cost so more people can buy the toothbrush and help the planet. Our optimal design uses a plant-based plastic handle and natural-fiber bristles. This toothbrush design has a medium environmental impact rating of 3.1, a clean-mouth rating of 84%, and costs \$2.08 per toothbrush.

DESIGN DECISIONS

Environmental impact: The proposed toothbrush design has an environmental impact rating of 3.1. Based on design feedback, we set a goal of an environmental impact rating of 3.5 or lower. We had another design with a lower impact rating of 1.9 with bamboo handle and natural-fiber bristles, but it didn't do well for other criteria. The handle we chose is made of a plastic that comes from plants and is meant to be recycled, and can slowly biodegrade, which means it is better for the environment. The bristles are natural fibers and are completely biodegradable. These materials are made from trees, which can break down in a compost or landfill without producing pollution.

Keeping mouths clean: Our design has a clean-mouth rating of 84%, which is better than our goal of 80%. We found that plastic bristles and natural-fiber bristles both removed at least 80% of



Not all toothbrushes are the same. They come in different styles and have different strengths and weaknesses.

plaque, and the more plaque removed, the less tooth decay there is, and the healthier people are. Therefore, we selected the natural-fiber bristles for our design. We had a cheaper design using nylon bristles (\$1.20 per toothbrush), but the clean-mouth rating for that toothbrush was only 53%. The plant-based plastic handle also affected the clean-mouth rating because the strength of the handle affects how much plaque is removed. Plastics are stiffer and help the person remove more plaque while brushing compared to more flexible handles made from all plant material.

Cost: Our proposed design costs \$2.08 per toothbrush. Our team tried to make a toothbrush that cost around \$1.90 based on our team goal. We had a plan that cost only \$1.20, but it had a high environmental impact and a very low clean-mouth rating. Plastic handles cost the least and plant-based plastic handles cost more but are still less expensive than all bamboo handles. Natural-fiber bristles cost more than nylon or plastic bristles. Since we didn't use the most expensive handles, our cost is still in an affordable range.

CONCLUSION: CONSIDERING TRADE-OFFS

We learned that toothbrush materials that work the best at cleaning the mouth are expensive and are not good for the environment. Toothbrush materials that are best for the environment don't do well at cleaning teeth and can also cost more. The cheapest handles were the worst for the environment but good at cleaning the mouth. The cheapest bristles were okay for the environment but not very good at cleaning the mouth. We focused on the criterion we think is most important: keeping mouths clean. Because we focused on the clean-mouth rating, the toothbrush costs more than other designs. Our proposed design is optimal because, even though it doesn't have the best environmental impact or cost, it is excellent at getting rid of tooth plaque which is important for keeping mouths, and people, healthy.



Toothbrushes can be made from many different materials.

Proposal Rubric

INTRODUCTION

Needs Improvement

Introduction is incomplete; missing one or more criteria and no mention of the proposed design

Developing

Lists the criteria of the project but does not describe them; mentions the proposed design by listing the results or details but not both

Proficient

Summarizes the design request and describes most criteria; describes the proposed design by listing the results or details but not both

Excels

Thoroughly summarizes the design request and describes the proposed design by listing the variables or details and the final results

DESIGN DECISIONS (same for each criterion)

Needs Improvement

No evidence is provided to support the design decision; explanation is inadequate or missing

Developing

Uses minimal evidence to support the design decision and does not explain why the specific feature was selected over other options and/or how that feature of the design relates to the criterion

Proficient

Uses some evidence to support design decision, mostly explaining why the specific feature was selected over other options and how that feature of the design relates to the criterion

Excels

Uses multiple pieces of strong evidence to support design decision, thoroughly explaining why the specific feature was selected over other options and how that feature of the design relates to the criterion

CONCLUSION: CONSIDERING TRADE-OFFS

Needs Improvement

Two or more of the following need attention: design priorities, summary of trade-offs in the optimal design, or a closing statement

Developing

One of the following needs attention: design priorities, summary of trade-offs in the optimal design, or a closing statement

Proficient

Includes all of the following, but may lack detail: design priorities, summary of trade-offs in the optimal design, and a closing statement

Excels

Description of design priorities is clear; summary of trade-offs in the optimal design is detailed and thorough; includes a strong closing statement

SCIENTIFIC COMMUNICATION

Needs Improvement

Lacks topic-specific vocabulary; uses informal style or language

Developing

Attempts to use topic-specific vocabulary and formal writing style, but needs improvement

Proficient

Uses some topic-specific vocabulary; uses formal writing style somewhat successfully

Excels

Uses topic-specific vocabulary clearly and appropriately; uses formal writing style successfully

Additional Resources



Tsunami Education

People who live in areas with a high risk of tsunamis can't just rely on a warning system to keep them safe. In these areas, tsunami education is a very important part of public safety.

People living in tsunami hazard zones are taught to run to higher ground if they feel an earthquake that lasts longer than 20 seconds. In some cases, that may be the only warning they have that a tsunami might be coming. When a tsunami gets close to shore, a loud roar from the ocean is one sign that might warn people nearby to move away from the ocean. The water may also pull back quickly from the shore, exposing the ocean floor. People can be taught to recognize these warning signs. It's also important for people to learn not to return to low-lying areas for several hours until after all the tsunami peaks have passed.

Many countries host tsunami drills to practice sending warnings through speakers, TV broadcasts, and even text messaging. Tsunami education, together with a good warning system, can save lives.

Chapter 7:

Engineering Glossary

analyze: to examine in detail for a purpose

analizar: examinar en detalle y con un propósito

argument: a claim supported by evidence

argumento: una afirmación respaldada por evidencia

convergent: moving toward the same place

convergente: que se mueven hacia el mismo lugar

criteria: standards by which something may be judged

criterios: normas por medio de las cuales se puede juzgar algo

deliverable: a thing to be delivered, usually in a development or design process

entregable: una cosa que debe entregarse, usualmente durante un proceso de desarrollo o diseño

divergent: moving apart in different directions

divergente: que se mueven y se separan en diferentes direcciones

dossier: a set of related documents about a particular topic

expediente: un conjunto de documentos relacionados sobre un tema particular

earthquake: a sudden shaking of Earth's surface

terremoto: una sacudida repentina de la superficie de la Tierra

engineer: a person who uses math and science to design things

ingeniero/a: una persona que utiliza las matemáticas y la ciencia para diseñar cosas

evacuate: to move somewhere safe

evacuar: moverse a un lugar seguro

evidence: information about the natural world that is used to support or go against (refute) a claim

evidencia: información sobre el mundo natural que se utiliza para respaldar o rechazar (refutar) una afirmación

false alarm: a warning that is generated for a specific area, even though no emergency or disaster occurs in that area

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patrón: algo que observamos que sea similar una y otra vez

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límite de placas: el lugar donde se juntan dos placas

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director/a de proyecto: la persona responsable de asegurarse de que se cumplan las metas de un proyecto

proposal: a formal design that is supported by evidence, and submitted for discussion and review

propuesta: un diseño formal respaldado por evidencia y presentado para discusión y revisión

request for proposals: a document asking engineers to submit a well-supported, formal design describing how they would solve a problem

solicitud de propuestas: un documento para pedir a los/as ingenieros/as que presenten un diseño formal, bien sustentado, que describa cómo resolverían un problema

scientific communication: the process of sharing scientific arguments, explanations, ideas, or data with an audience

comunicación científica: el proceso de compartir argumentos, explicaciones, ideas o datos científicos con un público

sensor: a device that detects information in its environment and responds

sensor: un aparato que detecta información en su ambiente y responde

subduction: the process by which rock material moves under Earth's outer layer and into the mantle due to plate motion

subducción: el proceso por medio del cual el material rocoso se mueve bajo la capa externa de la Tierra y hacia dentro del manto debido al movimiento de las placas

trade-off: when you have to give up one thing in return for another

concesión: una situación en la que se debe renunciar a algo para obtener otra cosa a cambio

transform boundary: a plate boundary where two plates move sideways past each other

límite transformante: un límite de placas donde dos placas se pasan de largo una a otra en dirección horizontal

trench: a long, deep indentation in the ocean floor formed when two plates move together

fosa: una hendidura larga y profunda en el piso oceánico que se forma cuando dos placas se juntan

tsunami: a large ocean wave caused by a sudden shift in the seafloor

tsunami: una gran onda oceánica causada por un cambio repentino en el piso oceánico

Plate Motion Engineering Internship Tsunami Warning Systems



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