NZ Transport Agency Rail Safety Resource – Primary – Level 1 to Level 4 Maths			
What is the big idea or focus?	**What is the key understanding – Why is it important for my students right now?**	**Driving question**	**Focus tasks for assessment** *Understanding and skills*
Citizenship. Mathematics and Statistics: Geometry and Measurement: Measurement, shape, position and orientation. In the context of keeping safe around the electrified rail network.	When you are a citizen you belong, you matter and you make a difference. Citizens work together to keep everyone safe around the electrified rail network.	What is worth knowing and doing as a citizen around places on the electrified rail network? **Stay away from overhead wires carrying electrical energy.** *The electrical energy that moves trains is always dangerous and always on.* *You cannot hear, see or smell electrical energy.* *The electrical energy is 100 times more powerful than the electrical energy used at home* *The electrical energy can jump gaps of up to 3 metres.* *When electrical energy passes through people, it kills or seriously injures them.* **Always use level crossings to get across the tracks.** *Trains on the tracks are very big, very fast and very quiet.* *Trains take a long time to stop.* *It is dangerous to take shortcuts and trespass.* **Watch out for the second train.** *Obey all warning signs and signals.* *Wait until all warning signs have stopped before crossing – there may be a second train.* *Look and listen in both directions.*	1. **Describe** a [measurement, shape, position and/or orientation] relevant to staying safe on the electrified rail network. [multistructural] 2. **Explain why** this [measurement, shape, position and/or orientation] helps citizens stay safe on the electrified rail network. [relational] 3. **Take action** to help citizens use [measurement, shape, position and/or orientation] to keep safe on the electrified rail network. [extended abstract]
Learning area Essence statement:	**Links to other learning areas**	**NZC Values**	**NZC Key Competencies:**
	All learning areas	Excellence	**Thinking** – Critically analyse the factors

Mathematics and statistics In mathematics and statistics, students explore relationships in quantities, space, and data, and learn to express these relationships in ways that help them to make sense of the world around them.		Innovation, inquiry, and curiosity Diversity Equity Community and participation Ecological sustainability Integrity Respect	contributing to safe electrified rail networks for all citizens. **Managing self** – Act responsibly when around the electrified rail network as a pedestrian, passenger, cyclist or driver to ensure all citizens keep safe. **Participating and contributing** – Display an awareness of the local issues around creating and maintaining safe electrified rail networks. Be actively involved in community issues around safe electrified rail networks. **Relating to others** – Interact with others to create safe electrified rail networks. **Making meaning from language, symbols and text** – Interpret and use language, symbols and text in ways that keep citizens safe around electrified rail networks.

Strand	**Achievement objectives** *Select the achievement objectives that best match the NZTA focus - concept and context - for your students*	**Suggested learning intentions** *(SOLO verbs – e.g. Define, Describe, Sequence, Classify, Compare / Contrast, Explain, Analogy, Analyse, Generalise, Predict, Evaluate, Create)* Use constructive alignment to design SOLO differentiated learning intentions (intended learning outcomes) to match the unit's content. http://pamhook.com/solo-apps/learning-intention-generator/
Geometry and measurement	***Level One*** ***Measurement*** *- Order and compare objects or events by length, area, volume and capacity, weight (mass), turn (angle), temperature, and time by direct comparison and/or counting whole numbers of units.*	**Define** "length". **Define** "distance". **Measure** jumps using conventional methods. **Use** chalk and metre rulers to measure out 3m (the distance electricity can jump from high-voltage wires). **Use** chalk and metre rulers to measure out the height of the contact wires from the ground on the electrified rail network. **Use** chalk and metre rulers to measure out the safe height restriction (5m) under a level crossing on the electrified rail network. **Use** chalk and metre rulers to measure out the distance of the

		yellow line from the edge of a platform. **Use** chalk and metre rulers to measure out the length (72m) of one of the new EMU trains in Auckland. **Order** the length of different jumps – e.g. standing jump, running jump, hop skip and jump, long jump. **Use** chalk and metre rulers to measure out the braking distance for the new EMU trains in Auckland. (Assuming a maximum braking rate of 1m/s/s, it will take over 30 seconds and 465 metres to stop the train when it is travelling at its top speed of 110km/h. It takes 22 seconds and approximately 242 metres to slow down from 80km/h. Many other variables affect the braking rate of the train.) **Compare and contrast** the distance covered in different jumps – including the jump distance of electricity from a high-voltage wire. **Compare and contrast** the distance of the yellow line from the edge of a platform with other safe distances marked out in public places.
	<u>Level One</u> ***Shape*** *- Sort objects by their appearance.*	**Identify** the shape of electrical hazard warning signs. **Sort** electrical hazard warning signs by their appearance.
	<u>Level One</u> ***Position and orientation*** *- Give and follow instructions for movement that involve distances, directions, and half or quarter turns.* *- Describe their position relative to a person or object.*	**Define** "half turn". **Define** "quarter turn". **Give instructions** for movement that involve distances, directions and half or quarter turns to locate [the source of a sound or the location of the yellow line on a station platform]. **Follow instructions** for movement that involve distances, directions and half or quarter turns to locate [the source of a sound or the location of the yellow line on a station platform]. **Describe** position in relation to [the source of a sound or the location of the yellow line on a station platform] .
	<u>Level Two</u> ***Measurement*** *- Create and use appropriate units and devices to*	**Define** "length". **Define** "distance". **Use** conventional and unconventional measures of different jumps

	measure length, area, volume and capacity, weight (mass), turn (angle), temperature, and time. *- Partition and/or combine like measures and communicate them, using numbers and units.*	– e.g. standing jump, running jump, hop skip and jump, long jump. **Use** chalk and metre rulers to measure out 3m (the distance electricity can jump from high-voltage wires). **Use** chalk and metre rulers to measure out the height of the contact wires from the ground on the electrified rail network. **Use** chalk and metre rulers to measure out the safe height restriction (5m) under a level crossing on the electrified rail network. **Use** chalk and metre rulers to measure out the distance of the yellow line from the edge of a platform. **Compare and contrast** data for the lengths of different jumps, including the distance electricity can jump, and communicate these findings using numbers and units. **Compare and contrast** the distance of the yellow line from the edge of a platform with other safe distances marked out in public places and communicate these findings using numbers and units.
	<u>Level Two</u> ***Shape*** *- Sort objects by their spatial features, with justification.* *- Identify and describe the plane shapes found in objects.*	**Sort** rail network safety signs by their spatial features. **Explain** why safety signs are classified in different groups. **Identify** the plane shapes found in objects on the rail network. **Describe** the plane shapes found in objects on the rail network.
	<u>Level Two</u> ***Position and orientation*** *- Create and use simple maps to show position and direction.* *- Describe different views and pathways from locations on a map.*	**Use** simple maps to show position and direction on a railway platform or level crossing. **Create** a simple map showing positions on a railway platform or level crossing. **Create** a simple map showing direction on a railway platform or level crossing. **Create** a set of directions to get from one position to another on the rail network. **Locate** position on a rail network map. **Describe** simple views and pathways from locations on a rail network map.

		Compare and contrast simple rail network maps; find similarities and differences.
	Level Three ***Measurement*** *- Use linear scales and whole numbers of metric units for length, area, volume and capacity, weight (mass), angle, temperature, and time.* *- Find areas of rectangles and volumes of cuboids by applying multiplication.*	**Define** "length". **Define** "distance". **Use** linear scales and whole numbers of metric units to determine the length of different jumps – e.g. standing jump, running jump, hop skip and jump, long jump. **Use** conventional measures to determine the direction (angle) of a sound source. **Use** conventional measures to measure out the distance of the yellow line from the edge of a platform. **Compare and contrast** data for the lengths of different jumps, including the distance electricity can jump, and communicate these findings using numbers and units. **Compare and contrast** the distance of the yellow line from the edge of a platform with other safe distances marked out in public places and communicate these findings using numbers and units. **Compare and contrast** data for the direction of different sounds heard with one ear, two ears, earbuds in ears, echoes or additional sounds in the soundscape. **Find** the area of different locations and structures on the rail network by multiplying the side lengths. **Use** a scale on a map and measure distance across larger areas.
	Level Three ***Shape*** *- Classify plane shapes and prisms by their spatial features.* *- Represent objects with drawings and models.*	**Identify** plane shapes and prisms by their spatial features. **Describe** plane shapes and prisms by their spatial features. **Classify** (sort) plane shapes and prisms by their spatial features. **Represent** the rail network and/or some of its physical infrastructure with drawings and models.
Geometry and Measurement	***Level Three*** ***Position and orientation*** *- Use a co-ordinate system or the language of*	**Define** "co-ordinate". **Give** instructions to specify location on the rail network – using co-ordinates. **Follow** instructions using co-ordinates to specify location on the

	direction and distance to specify locations and describe paths.	rail network. **Describe** position/location in relation to [the source of a sound or the location of the yellow line on a station platform] – using direction and distance. **Describe** position/location in relation to [the source of a sound or the location of the yellow line on a station platform] – using co-ordinates. **Use** simple co-ordinate grids to show position and direction on the rail network. **Locate** position on the rail network using simple co-ordinate grids. **Describe** simple pathways on the rail network using direction and distance. **Describe** simple pathways on the rail network using co-ordinates. **Create** a simple grid using co-ordinates to show position on the rail network. **Create** a set of directions using co-ordinates to get from one position to another on a simple grid mapping the rail network.
	Level Four ***Measurement*** *- Use appropriate scales, devices, and metric units for length, area, volume and capacity, weight (mass), temperature, angle, and time.* *- Convert between metric units, using whole numbers and commonly used decimals.* *- Use side or edge lengths to find the perimeters and areas of rectangles, parallelograms, and triangles and the volumes of cuboids.* *- Interpret and use scales, timetables, and charts.*	**Use** conventional metric measures to determine the length of different routes around your local rail network. **Convert** the length of different routes from metres to kilometres. **Use** the side or edge lengths of a location on the local rail network to measure the perimeter and area covered. **Calculate** the average time taken to travel different routes on the rail network. **Use** rail network timetables to create an itinerary for a trip using the Northern Explorer, Coastal Pacific train and TranzAlpine rail networks. **Use** a scale on a map to measure the distance travelled on the planned trip using the three rail networks.
	Level Four ***Shape*** *- Identify classes of two- and three-dimensional*	**Describe** the geometrical properties of two- and three-dimensional shapes found on the rail network. **Classify** (sort) two- and three-dimensional shapes found on the rail

	shapes by their geometric properties. *- Relate three-dimensional models to two-dimensional representations, and vice versa.*	network by their geometric properties. **Relate** three-dimensional models to two-dimensional representations of the physical structures on the rail network.
	<u>Level Four</u> ***Position and orientation*** *- Communicate and interpret locations and directions, using compass directions, distances, and grid references.*	**Define** "compass". **Describe** compass directions. **Use** compass directions to communicate location and/or direction. **Use** distances to communicate location on the rail network. **Use** grid references to communicate location and direction on the rail network. **Use** compass directions to interpret location and/or direction on the rail network. **Use** distances to interpret location on the rail network. **Use** grid references to interpret location and direction on the rail network. **Use** compass directions, distances and grid references to communicate locations and distances on the rail network. **Use** compass directions, distances and grid references to interpret locations and distances on the rail network.

Learning activities/learning experiences
Build learning activities and experiences for SOLO differentiated learning intentions.
Choose learning intentions that match your students' prior learning, interests and abilities.

Mathematics and Statistics:
Geometry and Measurement: Measurement, shape, position and orientation.

Think like a mathematician about staying safe on the electrified rail network.

What measurements, shapes, positions or orientations will help keep citizens safe on the rail network?

Determining prior knowledge, identifying misconceptions

Determining prior knowledge is a starting place for all learning.

Ask students to:

- Pause – clear your mind and then think deeply about the electrified rail network.
- Discuss the following question prompts in turn.
    - **Have you** or has anyone you know ever measured, counted or looked for patterns associated with the electrified rail network (terminal facilities, rail yards, railway stations, the tracks, level crossings, pedestrian overbridges, trains etc.)?
    - **What was it like?**
    - **What are** the measures and/or patterns you know to watch out for around the electrified rail network?
    - **What have you done** around the electrified rail network that could be dangerous?
    - **Why do you think** you behaved dangerously?
    - **What have you seen** other people do around the electrified rail network that could be dangerous?
    - **Why do you think** people act in potentially dangerous ways around the electrified rail network ?
    - **How do you feel** when you see people acting in potentially dangerous ways around the electrified rail network?
    - **What do you do** when you see people acting in potentially dangerous ways around the electrified rail network?
    - **What do kids need to know** about keeping safe around the electrified rail network?
    - **What do grownups need to know** about keeping safe around the electrified rail network?
- Record (write or draw) your answers to each question on separate Post-it notes.
- Label each Post-it note with the date.
- At the end of the discussion on each question, stick your answer onto a large sheet of newsprint labelled with the question prompt.
- Repeat this process with each question prompt.

Keep a record of the prior knowledge of your class.

SECTION 1: What is worth knowing and doing as a citizen around places on the electrified rail network?

Bringing in ideas
These activities provide opportunities for students to bring in mathematical ideas using measurement, shape, position and/or orientation to help citizens stay safe when using the electrified rail network.

Learning intention: Describe a [measurement, shape, position and/or orientation] relevant to staying safe on the electrified rail network. [multistructural]

Differentiated success criteria: We will know we have achieved this because ...

Multistructural	*My description has several relevant ideas about a* [measurement, shape, position and/or orientation] *relevant to staying safe when using the electrified rail network*
Relational	*.... and explains why these ideas are relevant*
Extended abstract	*... and makes a generalisation about the* [measurement, shape, position and/or orientation]*on the electrified rail network.*

Key Competency self-assessment rubric[1] Highlight the relevant Key Competencies for section 1.

Thinking	Managing self	Participating and contributing	Relating to others	Using language, symbols and text
Critically analyse the factors contributing to safe electrified rail networks for all citizens. *Example – describe, explain and justify ways to stay safe at places on the electrified rail network.*	Act responsibly when around the electrified rail network as a pedestrian, passenger, cyclist or driver to ensure all citizens keep safe. *Example – adopt a "sort it and report it" approach to unsafe behaviour around the electrified rail network.*	Display an awareness of the local issues around creating and maintaining safe electrified rail networks. Be actively involved in community issues around safe electrified rail networks. *Example – listen, respond and act together to make the electrified rail network a system free of death and serious injury.*	Interact with others to create safe electrified rail networks. *Example – demonstrate a commitment to safer outcomes for self, friends, family and whānau at places on the electrified rail network.*	Interpret and use language, symbols and text in ways that keep citizens safe around electrified rail networks. *Example – share safe rules and behaviours for places on the electrified rail network.*

[1] For draft versions of these Key Competency self-assessment rubrics, see the appendix.

1.0. Think like a mathematician about the electrified rail network
What measurements, shapes, positions and/or orientations will help keep citizens safe on the electrified rail network?

What is worth knowing and doing as a citizen and a mathematician around places on the electrified rail network?

- **Stay away from overhead wires carrying electrical energy.**
  - *The electrical energy that moves trains is always dangerous and always on.*
  - *You cannot hear, see or smell electrical energy.*
  - *The electrical energy is 100 times more powerful than the electrical energy used at home.*
  - *The electrical energy can jump gaps of up to 3 metres.*
  - *When electrical energy passes through people, it kills or seriously injures them.*
- **Always use level crossings to get across the tracks.**
  - *Trains on the tracks are very big, very fast and very quiet.*
  - *Trains take a long time to stop.*
  - *It is dangerous to take shortcuts and trespass.*
- **Watch out for the second train.**
  - *Obey all warning signs and signals.*
  - *Wait until all warning signs have stopped before crossing – there may be a second train.*
  - *Look and listen in both directions.*

Background: To explore the New Zealand rail network like a mathematician is to explore the maths and statistics of over 4,000 kilometres of track where passenger and freight trains are running faster, over longer distances and more frequently. The rail network is full of the patterns and relationships created when moving quantities of people and freight through space and time.

For example, when we claim the new electric trains on the Auckland rail network will hold more passengers, run more quietly, have less impact on the environment and have shorter journey times, a mathematician will ask – how many more, how much quieter, by what measure, how much shorter?

When we try to explain the dangers of the electrified rail network, we talk about numbers and patterns: the power is on 24 hours a day, the energy supply is 100 times more powerful than the home supply, the electrical energy in the live wires can arc (jump gaps) over 3m, the electric trains are much quieter than diesel locomotives. When we talk about the dangers of crossing the rail corridor, we explain that: trains cannot swerve, a fully loaded 3-car EMU electric train weighs 155 tonnes, and when it reaches speeds of 110km/h it takes over 30s and 465m to stop.

Rail networks are moving passengers and freight more frequently, over longer distances and at higher speeds than in the past. A whole new science of train and track measurement has developed as a consequence.

Introduce students to the measurement trains.

The measurement trains – The Flying Banana, Dr Yellow and Iris 320 – are trains that use the rail network to measure it so that freight and passengers travel safely.

You can see how they collect data to monitor the safety of tracks in the following YouTube video.

Network Rail: The New Measurement Train: http://youtu.be/WhVdTXh5XoA

For information on the measurement trains, see:

New measurement train: http://en.wikipedia.org/wiki/New_Measurement_Train
The Flying Banana: http://www.networkrail.co.uk/aspx/10924.aspx
Dr Yellow: http://en.wikipedia.org/wiki/Doctor_Yellow
Iris 320: http://en.wikipedia.org/wiki/SNCF_TGV_Iris_320

Discussion prompts
[think-pair-share, or small group or whole class discussion only]

What do you see? Why do you think it is like that? What does it make you wonder?

If you are a citizen using the electrified rail network, what is worth knowing about data, measurement, orientation, shape and position?

Watch videos showing parts of the New Zealand rail network.

For example:
KiwiRail Scenic video channel: http://www.youtube.com/user/KiwiRailScenic
KiwiRail Freight TVC 2013: http://youtu.be/W3fiCS2zTFc
KiwiRail Scenic Journeys | Take a break. Take a train: http://youtu.be/CORPm2QFdQ4
Auckland Transport: Auckland's New Electric Trains:
http://www.youtube.com/watch?v=484_FfGGBZg&list=PL442F15A82428642A
TNZ Videos: KiwiRail Freight and Passenger Action:
http://www.youtube.com/playlist?list=PLgREeRssJeWQXriO8qKPCTZlKrBENhiMV
Level Crossing: DC 4352 with the Overlander : http://youtu.be/P84rf87-SKQ
Level Crossing: Train 126 @ Kaukapakapa: http://youtu.be/sYgQYy301AQ
Level Crossing: Trains around Auckland (5 Barrier Arm Level Crossing): http://youtu.be/cPCo1-qyfVk
Tunnel: Northbound Overlander on the Raurimu Spiral: http://youtu.be/UhL8MsyPcgM
Station: Newmarket Railway Station: http://youtu.be/gRQ8Lbrha2g
Station: Helensville Freights: http://youtu.be/7Eg0q823ITU
Station: Overlander Departing Britomart: http://youtu.be/NTvh1ihNeC0
Station: Trains around Auckland: http://youtu.be/cPCo1-qyfVk
Masts: Northern Explorer speeding through Taumarunui: http://youtu.be/aWclHLtTLFQ

After watching the YouTube videos of the New Zealand rail network, ask students to visualise the network and to think about the mathematics and statistics of moving people and freight.

Say to students:

- Imagine yourself somewhere on the electrified rail network. Think about a particular structure or event on the electrified rail network in New Zealand – a rail yard, station, an overbridge or level crossing.
- Ask yourself, What measurements, shapes, positions or orientation will help keep me safe around this place?
- Imagine the rail network could answer questions about keeping safe. What maths questions would you like to ask the rail network? What questions would you have in particular for the station, the tracks, the overbridge, the pedestrian walkway, the level crossing, the railway yards, the park and ride areas?

Write these "what we know we don't know" maths questions on Post-it notes and display them on the classroom walls. Encourage students to add to them as they progress through the unit. Add a few of your own questions and invite any visitors to the class to add some as well.

1.1. What is a rail network?

Background: The New Zealand rail network

The New Zealand rail network is owned and managed by KiwiRail: http://www.kiwirail.co.nz It is focused on moving freight and has limited passenger services. The network consists of four main lines, seven secondary lines and many branch lines and covers over 4,000km of track in the North and South islands. The electrified sections of the rail network are located in Wellington, between Hamilton and Palmerston North, and in Auckland.

The electrified rail network uses electrical energy to make trains move.

The newly built trains (or electric multiple units, EMUs) on the Auckland electrified rail network use electrical energy to move. The trains use this electrical energy to carry up to 375 passengers along with their bicycles, pushchairs, wheelchairs, guide dogs and luggage at speeds of 110km/h. To transport 375 passengers in another way, you would need approximately 8 buses or up to 375 cars and they would have to travel much more slowly.

The electrified rail network has many advantages over the old diesel-powered network. It offers a faster, more environmentally friendly way for people to get around the city. The new train service is faster because the new trains powered by electrical energy can accelerate (and decelerate) twice as fast as the older diesel-powered trains. The new electric trains are also more energy efficient and quieter, and make no air pollution.

Citizens interact with the electrified rail network all the time: when waiting at the station platform for a train to arrive or depart; when travelling as passengers on trains using the rail network; and when crossing the rail network at level crossings or overbridges as pedestrians or cyclists, or in cars.

The electrified rail network has hazards as well as advantages. Electrical hazards include shock hazards, arcing hazards, blast hazards and possible electromagnetic field hazards from the high voltage used to transfer energy to the train. The electricity is never switched off so these hazards are always present on and around the rail network. You don't need to touch an electrified source to be electrocuted – high-voltage electricity can jump from one conductor to another. The electric wires over the track carry 25,000 volts, which is 100 times more powerful than the electrical energy used in homes. The electrical energy in the wires can jump a distance of 3 metres from the wires. Any activity that brings you or objects you are holding (like a kite) close to the live wires is highly dangerous. Even if the shock doesn't kill you, you will suffer horrible burns and injuries that will affect you for the rest of your life.

Other hazards are associated with the way trains move on the rail network. Heavy trains move along the track at high speeds (110km/h). They cannot swerve or stop quickly to avoid you. Adding to the danger, the electric trains move very quietly; you cannot hear them coming.

Because they are travelling at high speed, trains need a long distance to stop. By the time the driver sees someone on the tracks, the train cannot stop soon enough to avoid hitting them.

The high speed makes it hard for people to predict how far away the train is so they can make the wrong decision about when it is safe to cross. A train travelling at 110km/h takes only 5 seconds to travel 150m. Never try to “beat the train”.

Trains can travel in any direction, on any line, at any time. You can never be sure where the next train is coming from or which track it is using. Even when you are certain the first train has passed, you can be hit by the second train travelling at high speeds on the other track.

The high speeds also create turbulence. If you are standing too close to the tracks or the edge of the platform, you can be dragged under the train.

A train track on the electrified rail network is like a corridor overstuffed with dangers you cannot see, hear or control. For all these reasons, crossing the tracks as a pedestrian or cyclist or in a car will always be highly dangerous. The only safe way to get from one side of the tracks to the other is to use a railway overbridge, footbridge or level crossing.

There are many other safety systems and structures built into the rail corridor to keep people safe while they use trains. You can see these systems and structures at stations, on platforms and on trains and tracks.

Think about how a mathematician would define a network.

Background: Mathematicians would define a network as a collection of connected objects. They would refer to the objects as nodes (drawn as points) and the connections (drawn as lines) as edges.

Refer to:
Math Insight: An Introduction to Networks: http://mathinsight.org/network_introduction
Passy World of Mathematics: Network Mathematics: http://passyworldofmathematics.com/network-mathematics/
NRICH: Delia’s Routes: http://nrich.maths.org/202
NRICH: Networks and Nodes: http://nrich.maths.org/1068
NRICH: Redblue: http://nrich.maths.org/761
NRICH: Bands and Bridges: http://nrich.maths.org/2569

Discuss networks with students. Demonstrate how a network is a group of interconnected people, places and/or things. Watch commoncraft’s video, Social Networking in Plain English, on YouTube: http://youtu.be/6a_KF7TYKVc

Create network grids of desks or groups within the class, classes within the junior school, places to play in the playground, pathways that connect places in the school grounds. Use grids, meshes and webs to show how different people, places and things can be connected.

Mock up a simple rail network using a toy train set.

Draw a map showing stations as nodes and the connecting tracks as edges.

Identify your local rail network. Find the local rail network on a map. Use Google Maps http://maps.google.com/ to look at your local railway station, and locate railway yards, railway tracks, railway bridges and pedestrian level crossings. Follow the tracks to see where the tracks come from and where they go. Where are the stations that connect to the local station? Walk around part of your local rail network that has public access, taking photos of the different places and structures linked to the network. Sketch a simple network map for your local station and related objects in the local environment.

Refer to different rail network diagrams:
New Zealand's National Rail Network:
http://www.transport.govt.nz/ourwork/rail/newzealandsnationalrailnetwork/
Auckland City Rail Link Map: http://transportblog.co.nz/2012/07/04/more-info-on-the-crl-announcement/
Mappery: Auckland Rail Map: http://www.mappery.com/Auckland-Rail-Map
Wikipedia: List of Wellington Railway Stations (Tranz Metro network):
http://en.wikipedia.org/wiki/List_of_Wellington_railway_stations
Mappery: North Island Rail Map: http://www.mappery.com/North-Island-Rail-Map
Maps of the National Rail Network (UK):
http://www.nationalrail.co.uk/stations_destinations/maps.aspx
India Railway Map: http://www.mapsofindia.com/maps/india/india-railway-map.htm
Transport for London: London Overground and National Rail:
http://www.tfl.gov.uk/gettingaround/9444.aspx
World Map – Major Rail Network: http://www.mapsofworld.com/world-maps/major-rail-network-map.html

Discussion prompts
[think-pair-share, or small group or whole class discussion only]

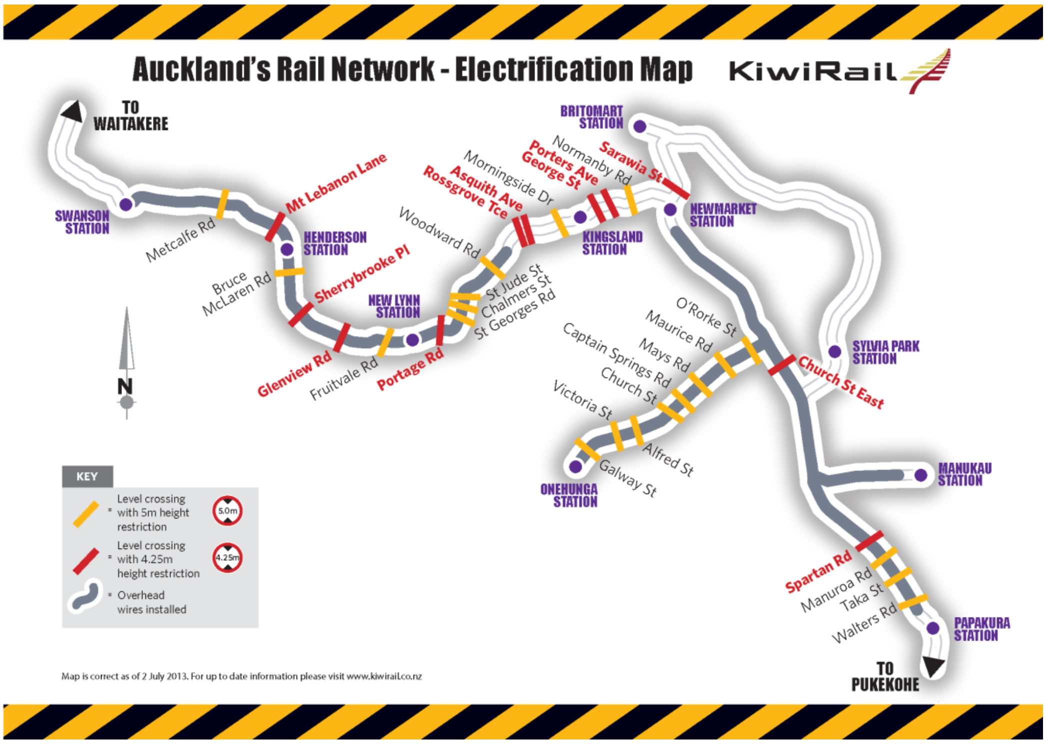
Look at a map of the rail network.

What do you see? Why do you think it is like that? What does it make you wonder?

If you are a citizen using the electrified rail network, what is on maps of the rail network that is worth knowing about?

Model or map your local network using photos and drawings of different places and people from your local or national rail network – railway station, railway yards, railway tracks, and railway bridges or pedestrian level crossings. Ask students to make connections between the images and/or items and to explain why they think they are connected.
Co-construct a class definition for "rail network" – e.g. "We think the rail network is ...". Include reasons and examples in the class definition. Revisit your rail network diagram and definition as students deepen their understanding throughout the unit.

Extension: Create a network map to show a student perspective of the important or relevant nodes in your local rail network. Share it with your local community. For example, see the KiwiRail Auckland Rail Network Electrification Map below (from http://www.kiwirail.co.nz/projects/major-projects/auckland-rail-electrification.html).



1.2. What is the rail network like?

Describe the attributes of the rail network:

- Describe the **physical infrastructures** of the rail network from a mathematical perspective – using measurement, position and orientation and shape.
- Describe the **administrative processes and regulations** of the rail network from a mathematical perspective.
- Describe the **personnel and management** of the rail network from a mathematical perspective.
- Describe the **people and freight** being moved by the rail network from a mathematical perspective.

The following components make up the rail network and could be used in your descriptions:

- physical assets –
  - terminal facilities
  - rail yards
  - railway stations
  - tracks
  - overhead wires and masts
  - rail substations
  - level crossings
  - overbridges and pedestrian walkways
  - tunnels
  - bridges
  - signage
  - signalling systems
  - communication systems
- administrative processes and regulations – including timetabling
- personnel and management required to repair tracks, sell tickets, schedule trains etc.

What are the physical dimensions of each? How many? How heavy? How big? How fast? How slow? How long? How far? How often? What shape? What is the pattern? What are the closed 2-D plane shapes? What are the 3-D shapes?

Example
Identify and describe the closed 2-D plane shapes found in objects, signs and structures on the rail network.
Look for:

- triangles (2-D flat shapes with three sides and three corners)
- rectangles (2-D flat shapes with four sides and four corners. Opposite sides are of the same length)
- squares (2-D flat shape rectangle with all four sides of equal length)
- circles (2-D flat shape with no sides or corners).

Identify safety signage on the rail network. Sort or classify the safety signs by their spatial features. Explain why signs are classified in different groups. Explain why these and other mathematical dimensions and perspectives are important in understanding the rail network.

Identify and describe the 3-D solid shapes and prisms found in physical assets, objects and structures on the rail network. Look for cubes (rectangular prisms), spheres, cones, cylinders and pyramids. Annotate the 3-D objects identified with their spatial features.

Describe the geometrical properties of two- and three-dimensional shapes found on the rail network.

Classify (sort) two- and three-dimensional shapes found on the rail network by their geometric properties.

Extension: Represent the rail network and/or parts of its physical infrastructure with mathematical shapes, 2-D drawings and 3-D models.
Relate three-dimensional models to two-dimensional representations of the physical structures on the rail network.

1.3. Describe an object/place/environment on the rail network – something that you care about, that is useful to you or that influences or challenges you
The rail network is often described through data. For example, the publicity material released on the new electrified trains in Auckland reveals they weigh 155 tonnes (weight of 3 cars, fully loaded), have an overall length of 72m (3 cars), use a 25kV AC overhead power supply, have 12 doors (4 per car) with 1.45m open width, have a maximum acceleration rate of 1m/s/s and a maximum braking rate of 1m/s/s.

Use mathematical measures, orientation, position and shapes to describe the attributes (characteristics) of a place on the rail network e.g. platform, station, tracks, rail yards, level crossing.

Choose an object/ place/ environment on the rail network that you care about, that is useful to you or that influences or challenges you when you are trying to keep safe on the rail network.

Look at photographs, video, schematic diagrams, building plans, sketches, Google Maps, scale models and timetables, and visit this place (under supervision) on the rail network.

Example

- Ask how long is the yellow line? What is its orientation with respect to the edge of the platform? How far is it from the edge of the platform? What area of the platform is off limits for people waiting to catch a train?

- Ask how tall are the masts carrying the catenary and contact wires? What shape are the tension supports for the contact wire? What are the geometric shapes in a pantograph? What are the shapes of the safety signage at a rail station?
- Ask what is the orientation of the tracks between two stations? How frequently do trains travel along the tracks – during a day, across a week, over a year? What time of day do trains travel on the tracks? How long does it take to travel between two stations on a passenger train? How long does it take freight to travel between stations?

Use Google Maps http://maps.google.com/ to locate a place on the rail network in your local area and mark the locations. Use Google Street View to see the locations from different orientations. Get students to plan several different routes that the class or their family could use to walk to your local station. Note any places where the route will cross the railway lines at a level crossing.

At the station – use conventional metric measures to determine the length of different routes around your local rail network. Measure the distance and length of the route, the station platform, the number and height of the platform steps etc. Identify different shapes and cuboids at the station. Mark these on a map.

Convert the length of different routes from metres to kilometres and from kilometres to metres.

Order the routes to the station in terms of how long you estimate it would take to walk along each one. Walk each walking route and check on the accuracy of your ordering. If an average person can walk 2 kilometres in half an hour, identify how long it would take to walk from station A to station B if the electrical power supply failed and all the train services stopped working during an emergency.

Use the side or edge lengths of a location on the local rail network to measure the perimeter and area covered.

Use Google Maps http://maps.google.com/ to measure the dimensions, length, perimeter and/or area of different places on the rail network.
Use the Google Maps line tool to measure the distance you travel walking to a place on the rail network.
Use the Google Maps shape tool to measure perimeter and area of the places on the rail network.

Build a scale model of an EMU (or station platform) using old cardboard cartons and other found materials.

Draw a model of the station platform using chalk in the playground or as a large wall display in the classroom.

For example, a railway station is made up of:
- a platform with signage and the yellow line
- a station building including ticket sales, waiting rooms and toilets
- communication systems (safety and arrival/departure information) – loudspeakers, signage, signals
- pedestrian and wheelchair access ramps, overbridges, steps
- luggage carts
- a drop-off and collect parking area
- a left luggage area
- a lost and found office
- taxi ranks
- bus bays.

Identify features that you care about, features that are useful and features that are hazardous and need to be managed if you are to be safe on the rail network. Identify any features of the place designed to keep people safe.

For example, the following KiwiRail web pages describe features that are hazardous in the electrified rail network and how to manage them.

Live Wires: http://youtu.be/2TQ6QCs4rqo
Staying Safe around the Electrified Rail Network: http://www.kiwirail.co.nz/projects/major-projects/auckland-rail-electrification/auckland-electrification-safety/staying-safe.html
Level Crossings: http://www.kiwirail.co.nz/projects/major-projects/auckland-rail-electrification/auckland-electrification-safety/level-crossings.html
If You Live Next to the Rail Tracks: http://www.kiwirail.co.nz/projects/major-projects/auckland-rail-electrification/auckland-electrification-safety/living-next-door.html

Discussion prompts
[think-pair-share, or small group or whole class discussion only]

Think like a mathematician when you look at this place on the rail network.

What do you see? Why do you think it is like that? What does it make you wonder?

If you are a citizen using the electrified rail network, what is worth knowing about this place on the rail network?

The following subsections will help you think like a mathematician when describing a place on the rail network.

1.3.1. What are the length, height and distance of places on the rail network?

Background: The masts carrying the electrified overhead wires will be 6–7m tall and the wires will be directly over the rail tracks.
The electric wires over the track carry 25,000 volts, which is 100 times more powerful than the electrical energy used in homes.
The wires are live all the time. They are never switched off.
You don't have to touch the wires to get electrocuted.
The wires are extremely dangerous and potentially deadly to anyone who contacts them or comes too close to them, as electricity can arc (jump) across gaps of up to 3 metres and can also travel through water or other liquids. People are mostly made of water.
It is important to keep right away from these wires and to make sure anything you may be carrying or playing with is also well clear. Playing with kites or balloons near the wires is dangerous, as is throwing objects at the wires.
Screening will be in place to prevent any accidental contact at bridges or alongside walkways.

Adapted from KiwiRail's Frequently Asked Questions: http://www.kiwirail.co.nz/auckland-s-electrification---frequently-asked-questions

Discuss the terms "length" and "distance" with students.

- When we ask how tall something is, how long it is or how wide it is, we are asking about length. Length: How long or wide something is. Length is usually measured in millimetres (mm), centimetres (cm), metres (m) or kilometres (km).
- When we ask how far apart or close together something is, we are asking about distance. Distance: How far apart or close together two objects are.

Watch a YouTube video showing overhead wires and electrified trains moving on the tracks.
Refer to:

Completed wires out near Swanson: http://transportblog.co.nz/2013/05/13/electrification-project-running-late/
Railway Technical: Overhead Line – Catenary: http://www.railway-technical.com/etracp.shtml#Overhead-Line-Catenary
Catenary and Pantograph: How Does It Work? http://youtu.be/kFPJ8eF9M2A
Sparking Matangi Electric Train at Silverstream, Upper Hutt, New Zealand: http://youtu.be/sPxG4W4mDhE
High Speed Beaujolais and Pantograph Action: http://youtu.be/A0G14ee3tR8

Co-construct a class definition for "distance" – e.g. "We think distance is …". Include reasons and examples in the class definition. Revisit your definition as students deepen their understanding throughout the unit.

1.3.1.1. What is the distance that electrical energy can jump from the high-voltage wires above the train tracks?

Background

- Always stay clear of electric wires, and never touch them or throw objects at them.
- The electricity can "jump" up to 3m, or pass through objects, and you can be electrocuted without even directly touching the overhead wires.
- In New Zealand, people have been severely burned or have died from coming into contact with overhead electric wires.
- Overhead electric wires on the railway are live and dangerous even when trains are not running.

Refer to: Safety around Overhead Wires: http://www.railsafety.co.nz/keeping-safe/safety-around-overhead-wires

Ask students to estimate how far a 3m jump would be. Can they jump 3 metres?

Note: Farthest long jump by a male = 8.95m (29ft 4.36in), Mike Powell (USA) in Tokyo, Japan, 30 August 1991
Farthest long jump by a female = 7.52m (24ft 8.06in), Galina Chistyakova (USSR) in Leningrad, USSR (now St Petersburg, Russia), 11 June 1988

Measure students' jumps using conventional methods. Include standing jumps and running jumps etc. Record the data in a tally chart.

Order the length of different jumps e.g. standing jump, running jump, hop skip and jump, long jump.

Use chalk and metre rulers to measure out 3m (the distance electricity can jump from high-voltage wires).

How many students could jump 3m or further?

Sequence (order) the jump distances of individual students along with the jump distance of the electrical energy in the high-voltage wires.

Extension: Compare and contrast the lengths of different jumps, including the distance electricity can jump, and communicate these findings using numbers and units.

1.3.1.2. What is the distance of the electrified wires above a train track?
Ask students why the masts carrying the overhead wires are so high.

Estimate the distance the wires would be from the ground with respect to a classroom or other objects in the playground.

Measure the height of different objects around the school using conventional methods. Discuss the limitations when trying to measure height.
Use chalk and metre rulers to measure out 7m across the playground (the height of the masts holding up the high-voltage wire or height of contact wires).
Measure the height of students in the class.
How many students would it take to reach a height of 7m?
Find structures in the school that seem to have a height equivalent to the electrified wires.

Extension: Find out ways of measuring the height of very tall structures using shadows, sight lines or angles. Refer to HowStuffWorks:
http://science.howstuffworks.com/engineering/structural/question379.htm

1.3.1.3. What is the distance of the yellow line from the edge of the station platform?

Background: Many station platforms have a horizontal yellow warning line to keep passengers away from the tracks when they are waiting for a train. Some also include textured zones of raised bumps. Others have introduced pedestrian barriers. The greater the speed of the passing train, the greater the platform buffer distance needed to be safe from the backdraft or an accidental stumble or trip.

Rail Safety New Zealand (http://www.railsafety.co.nz/keeping-safe/platforms-and-stations) advises that:

- Not all trains stop at ALL stations.
- Some express trains and freight trains may travel through at high speed without stopping. Always expect a train on a platform and **stand at least 1.5 metres away** from the platform edge.
- Fast trains can create a vacuum called a “back draft” that can blow you over or suck you under a train.
- Under no circumstances should you ever sit on the edge of a platform.
- In New Zealand, people have died from being hit by a train while sitting on a station platform.

Use the 1.5m measure or contact your local railway station to find out the actual position of any yellow line or textured zones on the platform of your local station. Note: Do not suggest students collect these data.

Mock up a model platform in the playground or other large open space.

Use chalk and metre rulers and the 1.5m measure to mark out the position of the yellow line or textured surface on the "model platform". Add a yellow line to your model platform.

Alternatively use chalk to mark out 1.5m pedestrian buffer zones at relevant (trip hazard) locations across the school.

Refer to:
Humans in the Design of Yellow Lines: http://humansindesign.com/post/23699155244/humans-in-the-design-of-yellow-lines
MRT Platform Buffer Distance Insufficient: http://ride.asiaone.com/news/general/story/mrt-platform-buffer-distance-insufficient

Extension: Compare and contrast the distance of the yellow line from the edge of a platform with other safe distances marked out in public places and communicate these findings using numbers and units.

1.3.1.4. What is the braking distance for heavy electrified trains moving at 110km/h?
Ask students why drivers cannot stop trains when they know someone or something is on the tracks.

Background: Assuming a maximum braking rate of 1m/s/s, it will take over 30 seconds and 465 metres to stop the train when it is travelling at its top speed of 110km/h. It takes 22 seconds and approximately 242 metres to slow down from 80km/h. Many other variables affect the braking rate of the train.

Use chalk and metre rulers to measure out the braking distance for the new EMU trains in Auckland.

Use this measure to help students understand why a train driver cannot stop in time to avoid hitting pedestrians or cars trespassing on the rail track.

1.3.1.5. What are the maximum and minimum distances covered by a train trip using the Northern Explorer, Coastal Pacific train and TranzAlpine rail networks?
Calculate the average time taken to travel different routes on the rail network.
Use rail network timetables to create an itinerary for a trip using the Northern Explorer, Coastal Pacific train and Tranz Alpine rail networks.
Use a scale on a map to measure the distance travelled on the planned trip on the three rail networks.

1.3.1.6. What other distances are important for keeping safe on the rail network?
Think of other distances that are important if citizens are to keep safe at or around the electrified rail network.

Example
Use chalk and metre rulers to measure out the safe height restriction (between 4.25m and 5m) under a level crossings on the electrified rail network.
Use chalk and metre rulers to measure out the length (72m) of one of the new EMU trains in Auckland.

Extension: Give instructions to specify a location on the rail network – using distance. (How far away is X from Y?) Use conventional and/or unconventional measures to specify the distance of a safe position to wait for the train on the station platform. For example, How far back from the platform edge is a position behind the yellow line on a station platform?

1.3.2. Direction, orientation and co-ordinates on the rail network: Where is it? Are we there yet? Where is here?

Background: When you describe the "direction" of something, you talk about its position with respect to another object without providing any distance information. You can show direction by simply pointing a finger or by using arrows on signs. The signage at New Zealand rail stations uses arrows to communicate direction of different platforms, toilets, escalators, lifts, telephones, taxis etc.

The language for giving directions involves terms like "left", "right" and "straight ahead".

Mathematicians have other ways to measure direction using angles and vector co-ordinates. A magnetic compass uses the co-ordinates north, south, east and west against a stationary frame of reference relative to the surface of the earth. GPS receivers and smart phones can be used like a compass to look at direction.

Direction matters when using the rail network. It is important to check on the direction of an oncoming train when you are crossing the tracks at a level crossing. Even if a train has passed, always check that a second train is not coming in the opposite direction. Two tracks means there might be a second train. Directions help when you are trying to find the right platform or train to get to your destination. Directions help when you are looking for the toilets or the station exits.

The very best instructions for "How to get there" do not come from orientation, angles, bearings or vector co-ordinates. They come from Melbourne philosopher and cartoonist Michael Leunig's poem – "How to get there": http://www.leunig.com.au/index.php/works/poems

1.3.2.1. What is the direction?
Read Leunig's poem "How to get there".

Discuss the term "direction' with students. What is a direction? What does a direction mean?

Make up a set of direction vocabulary cards with arrows that use the language for giving directions. For example:
Direction – Left: go left, turn left, take a left, take the second (turning) on the left.
Direction – Right: go right, turn right, take a right, take the second (turning) on the right.
Direction – Ahead: go ahead, go straight ahead, go straight on.

Use the cards if required to give and follow directions:

Give directions to move one or more students around cones set out in a grid pattern in an open area in the playground or gymnasium or around the school campus.
Follow directions to move around cones in an open area in the playground or gymnasium or around the school campus.

Give directions for getting from point A to point B on a simple grid map.
Follow directions to get from point A to point B on a simple grid map.

Give directions for getting from point A to point B (a specific location on the rail network – e.g. rail platform, level crossing). Use a map of the local area around the rail network.
Follow directions for getting from point A to point B (a specific location on the rail network – e.g. rail platform, level crossing). Use a map of the local area around the rail network.

Discussion prompts
[think-pair-share, or small group or whole class discussion only]

Think like a mathematician when giving and following directions.

What do you do? Why do you think it is like that? What does it make you wonder?

If you are a citizen, what is worth knowing about giving and following directions on the electrified rail network?

Co-construct a class definition for "direction" – e.g. "We think direction is …". Include reasons and examples in the class definition. Revisit your definition as students deepen their understanding throughout the unit.

Extension: Give and/or follow instructions **using direction and distance** to specify location on the rail network.

1.3.2.2. What is the orientation?

Background: The new electric trains are very fast and very quiet. It is hard to hear them coming and even harder to determine the direction they are coming from when you are using a level crossing to get safely across the tracks. Where there are double tracks, the situation is even more dangerous – when one train has passed, another train may be coming from the other direction.
Stop, look both ways and listen for trains Wait until a train has passed and look both ways again – a train may be coming in the opposite direction. Always look out for the second train.

Note:
Only ever cross the railway at a formed pedestrian crossing or at a designated overpass or underpass.
It is illegal to cross the railway tracks at any point other than an official pedestrian crossing.
Keep to the path and always stop, look and listen for trains.
Remember:

- Obey the warning signs at the crossing.
- Look for trains both ways up and down the tracks.
- Only cross if you are sure there are no trains in sight.
- If lights are flashing or bells ringing, this means a train is approaching.
- If there is a pedestrian swing gate, wait until the gate opens fully before entering the crossing.

With modern technology it may be hard to hear a train approaching.

Always remove your iPod or MP3 player when near railway tracks and never talk on a cell phone while around railway tracks.

Adapted from Rail Safety:
Advice for Pedestrians: http://www.railsafety.co.nz/keeping-safe/advice-for-pedestrians
Safety Around Double Tracks: http://www.railsafety.co.nz/keeping-safe/safety-around-double-tracks

Play a sound orientation game to introduce the orientation language of "half turn" and "quarter turn".

Play **Marco Polo** in a marked-off area on the playing field (or in the swimming pool). One person is chosen to be IT. During the game, IT must keep their eyes closed. The other players can keep their eyes open as they move in slow motion within the outlined area. IT has to tag other players using sound to locate them. Every time IT calls out “Marco”, the other players must reply “Polo”. Any person tagged becomes the new IT.

Discuss how IT was able to find the other players by **turning towards** the source of the sound.

Demonstrate how to measure a turn as a “quarter turn” and a “half turn”.

Model moving through quarter turns and half turns in response to student directions.

Get students to follow instruction to move through a quarter turn and a half turn.

Play Simon Says with instructions that use “half turn” and “quarter turn”.

Ask students to make (and/or follow) sets of written or spoken instructions involving walking different distances, and making quarter turns and half turns to get to an unidentified location.

Use “quarter turn” and “half turn” to describe directions on a map of the local area.

Demonstrate left and right (and/or clockwise and counter clockwise) directions.

Play Simon Says with instructions that use quarter turns and half turns in left and right, or clockwise and counter-clockwise, directions.

Play **Where’s the sound coming from?** using orientation language.

- One person wearing a blindfold sits on a chair in the middle of an open space. The other students form a large circle around the person on the chair. Mark their positions relative to the person on the chair: directly in front of or behind the person, a quarter turn or half turn away from the person etc. The co-ordinator points to one of the students in the circle, who says the name the seated person. The seated person points in the direction of the noise and describes the position of the person who spoke in terms of full, half and quarter turns.
- Repeat the activity but this time the person in the chair listens only with the left ear, only with the right ear, while using ear buds and with other students talking. Does listening with both ears rather than only one make it easier to determine the direction of the sound? How does wearing ear buds or listening to an mp3 player or talking on a cell phone affect the ability to tell direction?
- Repeat the experiment but add background noise. How does other noise affect the ability to tell where a sound is coming from?

Discussion prompts
[think-pair-share, or small group or whole class discussion only]

Think like a mathematician when you listen to where the sound comes from.

What do you hear? Why do you think it is like that? What does it make you wonder?

If you are a citizen using the electrified rail network, what is worth knowing about identifying where sound comes from on the rail network?

Co-construct a class definition for “orientation” – e.g. “We think orientation is ...”. Include reasons and examples in the class definition. Revisit your definition as students deepen their understanding throughout the unit.

Extension: Create a "this is not a map" map of your school, local community or local railway station that visitors could use to get around. Use only words to give directions for a walk across the school. Use arrows to show orientation and the number of strides to indicate distance between point A and point B. Create a mathematical argument against the banning of maps.

1.3.2.3. What is a map?

Explore different forms of mapping (map of the seating arrangements in a classroom, map of school, map of the civil defence evacuation areas, map of local area, road maps, Google Maps, treasure maps, early world maps, navigational charts, **rail network maps**, station maps etc.).
Refer to:
Proposed City Rail Link maps: http://www.aucklandtransport.govt.nz/improving-transport/city-rail-link/Pages/default.aspx
Newmarket Train Station 3D Diagram: http://www.gardyneholt.co.nz/government-council/1384/newmarket-train-station-3d-diagram/
Schematic Map: http://www.gardyneholt.co.nz/government-council/1385/schematic-map/
Grafton Station Map: http://www.gardyneholt.co.nz/government-council/1383/grafton-station-map/
Auckland Transport Link - http://www.gardyneholt.co.nz/government-council/1474/auckland-transport-link/

Explore less conventional forms of mapping (circuit diagrams, map of your palm, x-rays, body maps, maps of eyes, thumbprints, house plans, starmaps, molemaps, mindmaps, mazes, horizontal and vertical distribution maps of shellfish, tactile maps, olfactory maps etc.).
Refer to:
Strange Maps: http://bigthink.com/blogs/strange-maps
40 Maps that Will Help You Make Sense of the World: http://twistedsifter.com/2013/08/maps-that-will-help-you-make-sense-of-the-world/
A Collection of Very Strange Maps: http://io9.com/a-collection-of-very-strange-maps-479288345
If You Thought Apple's Maps Were Weird, Look at These:
http://www.theguardian.com/commentisfree/interactive/2012/sep/07/weird-maps-to-rival-apple-in-pictures

List the attributes of a map. What do maps have in common?
Compare and contrast different maps of the local rail network (or rail station) (e.g. as it appears on a road map and a Google satellite map). Look at the different ways of viewing a place that Google Earth offers (satellite view, terrain view, road map etc.). What are the differences and the similarities between views?

Discussion prompts
[think-pair-share, or small group or whole class discussion only]

Think like a mathematician when you look at a map of the rail network.

What do you see? Why do you think it is like that? What does it make you wonder?

If you are a citizen using the electrified rail network, what is worth knowing about this map of the rail network?

Co-construct a class definition for "map" – e.g. "We think a map is …". Include reasons and examples in the class definition. Revisit your map diagram and definition as students deepen their understanding throughout the unit.

Extension: Think about what life would be like if all maps were banned.
Look at existing visitor maps of the school, local community and local railway station. What information is missing from a student perspective? Create a map to provide the missing information. Compare your map with those of other students. Use the best features from all the maps to create a new visitor map for the school, local community or rail network.

1.3.2.4. What are the co-ordinates?

Background: Co-ordinates are a set of values that show an exact position. We use co-ordinates on maps and graphs to show where a point is: the first number shows the distance along and the second number shows the distance up or down.

Use simple 5 by 5 and 10 by 10 grid games, treasure maps, battleships etc. to show students that when plotting co-ordinates you move across the grid first and then up or down the grid.

Create a classroom-sized grid by stretching string lines across the classroom. Identify the origin (0,0). Describe the co-ordinates of different people or objects in the room.

Create a classroom-sized grid by using student chairs or tables as points on the grid. Identify the origin (0,0). Move students around the room by calling out instructions based on the rows and columns and co-ordinates.

Create a treasure hunt grid in the field with prizes hidden in small containers. Take turns to throw dice to claim a container.

Introduce students to grid lines of latitude and longitude on a globe and wall map. Describe the co-ordinates of different countries using latitude and longitude.

Use positive number grids, positive *x* axis, positive and negative *y* axis; and positive and negative *x* and *y* axes grids.

Discussion prompts
[think-pair-share, or small group or whole class discussion only]

Think like a mathematician when you use co-ordinates to show a position on a grid.

What do you do? Why do you think it is like that? What does it make you wonder?

If you are a citizen using the electrified rail network, what is worth knowing about using co-ordinates to show position on the rail network?

Co-construct a class definition for “co-ordinates” – e.g. “We think co-ordinates are …”. Include reasons and examples in the class definition. Revisit your definition as students deepen their understanding throughout the unit.

Extension: Create a grid game for other students, using co-ordinates to specify different locations on the rail network.

1.3.2.5. Describe the position/location of an object on the rail network in your local area

For example, describe the source of the sound of an approaching train, the location of the yellow line on a station platform, the location of the rail station or a pedestrian level crossing in your local area:

- **using direction and distance**
- **using co-ordinates.**

Extension: Describe a simple pathway on the rail network in your local area. For example, describe the route from the school to a railway level crossing. Using direction and distance and using co-ordinates

1.3.2.6. Describe the orientation of an object (or a sound) on the rail network in your local area
Ask students how good they are at finding a lost cell phone. Ring a cell phone that has previously been hidden in the room. Ask students to stay seated and work independently to describe the location (direction and distance) of the ringing phone using mathematical terms of measurement and orientation. Each student then pairs up with two other students and the group uses the three individual descriptions to better identify the location.
The groups share their locations with the class before you ring the phone for a second time and students locate it. How easy was it to reliably locate the phone using sound alone? What were the barriers to accurately describing the location?

Watch the following Network Rail videos that demonstrate how well people can locate the orientation of an approaching train:
Track Tests – Wretch 32 and George the Poet: http://youtu.be/N4ul6lh0XQ8
Behind the Scenes of Track Tests with Wretch 32 and George the Poet: http://youtu.be/3ouSHOZRH6M

Give instructions for movement that involve distances, directions and orientation – use half or quarter turns to locate the pre-recorded sound of an approaching train on a level crossing.

Follow instructions for movement that involve distances, directions and half or quarter turns to locate the source of a recorded train sound. Write a description of the location of the sound relative to a person waiting at the crossing or station.

For pre-recorded train sound effects, refer to:
Sound Jay: http://www.soundjay.com/train-sound-effect.html
Freesound: http://www.freesound.org/search/?q=trains
SoundDogs: http://www.sounddogs.com/results.asp?Type=1,&CategoryID=1053&SubcategoryID=37
Shockwave Sound: http://www.shockwave-sound.com/track_search.php?track=trains
SoundBible: http://soundbible.com/1618-Freight-Train.html
AudioJungle: http://audiojungle.net/search?utf8=%E2%9C%93&term=train
RoyaltyFreeMusic: http://www.royaltyfreemusic.com/sound-effects.html

Give instructions for movement that involve distances, directions and orientation. Use half or quarter turns to describe the location of a mock-up of the yellow line on a station platform.

Follow instructions for movement that involve distances, directions and half or quarter turns to locate the location of the yellow line on a chalk model of a station platform. Write a description of the location of the yellow line relative to a person at the station (or relative to the edge of the platform).

Set up an obstacle course in the classroom or outside on the field. Students work in pairs. One student writes directions involving distances, directions and orientation to guide a second student to a safe waiting zone on the platform. They direct the blindfolded student around the obstacle course to the safe waiting place using only spoken directions. Give students several attempts at improving their instructions.

Discussion prompts
[think-pair-share, or small group or whole class discussion only]

Think like a mathematician when you use co-ordinates, distance and direction to describe the location of an object (or sound) on the rail network.

What do you see/hear? Why do you think it is like that? What does it make you wonder?

If you are a citizen using the electrified rail network, what is worth knowing about using co-ordinates, distance and direction to describe the location of an object (or sound) on the rail network?

Ask students to use their experience to describe the orientation of an object (or a sound) on the rail network in your local area.

Extension: Explain how describing the orientation of an object (or sound) on the rail network can help keep citizens safe.

1.3.2.7. Describe locations on the rail network using compass directions, distances and grid references
Show students a large image of a compass. Identify what it is and show how to use the compass to describe direction – such as north, south, west and east.

Demonstrate how to hold a compass and how a compass always points north (magnetic north).

Distribute orienteering style compasses – one for each pair of students. Ask students to hold the compass correctly and then use the compass to identify magnetic north.

Then ask them to identify the other main compass directions – south, west and east.

Then ask them to identify north east, north west, south east and south west.

Use the compass directions – north, south, west, east etc. – to describe the direction of local landmarks or structures relative to the person holding the compass.

Identify and demonstrate the use of the rotating bezel of a compass. The index marks (degree lines) on the bezel cut the 360-degree circle into 2-degree or 5-degree segments. The markings on the bezel allow you to measure the direction of a place on the rail network as the angle between a line pointing due north and line pointing to the place or object.

Explain how these index lines convert the general compass directions into specific bearings (with numeric value). The bearing lets people move towards a specific location rather than moving in a less accurate north to north east direction.

Demonstrate how to take a bearing using the bezel.

Let students practise using the bezel on a simple orienteering route set up around the school. Instructions should include direction and distance.

Get students to create their own orienteering route, communicating location and/or direction - around the school using compass directions and bearings.

There are many compass instruction sites online. For example:

American Hiking Society: Compass Basics: http://www.americanhiking.org/how-to-use-a-compass/
HowStuffWorks: Which Is Better for Navigation – compass or GPS?:
http://adventure.howstuffworks.com/outdoor-activities/hiking/compass-or-gps1.htm
Compass Dude: http://www.compassdude.com/

Discussion prompts
[think-pair-share, or small group or whole class discussion only]

Think like a mathematician when you use compass bearings to describe the location of an object on the rail network.

What do you see? Why do you think it is like that? What does it make you wonder?

If you are a citizen using the electrified rail network, what is worth knowing about the compass bearings for a place on the rail network?

Describe the location of a place on the rail network using bearings and distances.

Extension: Learn how to use a compass with a map. Use compass directions and a map of the local area to describe the location and/or direction of a place on the rail network. Use distances to describe location on a map of the rail network. Use grid references to interpret location and direction on a map of the rail network. Use compass directions, distances and grid references to communicate locations and distances on the rail network. Use compass directions, distances and grid references to interpret locations and distances on the rail network.

SECTION 2: Explain what is worth knowing and doing as a citizen around places on the electrified rail network

Relating ideas
These activities provide opportunities for students to connect ideas about place and the electrified rail network.

Learning intention: Explain why this [measurement, shape, position and/or orientation] helps citizens stay safe on the electrified rail network. [relational]

Differentiated success criteria: We will know we have achieved this because …

Multistructural	*My explanation has several relevant reasons why [measurement, shape, position and/or orientation] helps citizens stay safe on the electrified rail network*
Relational	*… and explains why these reasons are relevant*
Extended abstract	*… and makes a generalisation about the reasons.*

Key Competency self-assessment rubric[2] Highlight the relevant Key Competencies for section 2.

Thinking	Managing self	Participating and contributing	Relating to others	Using language, symbols and text
Critically analyse the factors contributing to safe electrified rail networks for all citizens. *Example – describe, explain and justify ways to stay safe at places on the electrified rail network.*	Act responsibly when around the electrified rail network as a pedestrian, passenger, cyclist or driver to ensure all citizens keep safe. *Example – adopt a "sort it and report it" approach to unsafe behaviour around the electrified rail network.*	Display an awareness of the local issues around creating and maintaining safe electrified rail networks. Be actively involved in community issues around safe electrified rail networks. *Example – listen, respond and act together to make the electrified rail network a system free of death and serious injury.*	Interact with others to create safe electrified rail networks. *Example – demonstrate a commitment to safer outcomes for self, friends, family and whānau at places on the electrified rail network.*	Interpret and use language, symbols and text in ways that keep citizens safe around electrified rail networks. *Example – share safe rules and behaviours for places on the electrified rail network.*

[2] For draft versions of these Key Competency self-assessment rubrics, see the appendix.

2.0. Why do [measurement, shape, position and/or orientation] help citizens stay safe on the electrified rail network?

2.1. Why should citizens stay away from overhead wires carrying electrical energy on the rail network?
Think like a mathematician. Use the measurements, shapes, and/or positions and orientations from the learning experiences in section 1 to explain why citizens should stay well away from the overhead wires on the rail network.

Draft your mathematical ideas on a HookED SOLO Causal explanation map.

Use the draft ideas to write, speak about or draw an explanation.

Self-assess the SOLO level of your explanation using the success criteria in the Key Competency self-assessment rubric above.

Extension: Identify a group of citizens in your local community who would be helped by knowing about and acting on these reasons.

2.2. Why should citizens only use level crossings to get across the tracks?
Think like a mathematician. Use the measurements, shapes, and/or positions and orientations from the learning experiences in section 1 to explain why citizens should only use level crossings to get across the tracks.

Draft your mathematical ideas on a HookED SOLO Causal explanation map.

Use the draft ideas to write, speak about or draw an explanation.

Self-assess the SOLO level of your explanation using the success criteria in the Key Competency self-assessment rubric above.

Extension: Identify a group of citizens in your local community who would be helped by knowing about and acting on these reasons.

2.3. Why should citizens watch out for the second train?
Think like a mathematician. Use the measurements, shapes, and/or positions and orientations from the learning experiences in section 1 to explain why citizens should always watch out for the second train.

Draft your mathematical ideas on a HookED SOLO Causal explanation map.

Use the draft ideas to write, speak about or draw an explanation.

Self-assess the SOLO level of your explanation using the success criteria in the Key Competency self-assessment rubric above.

Extension: Identify a group of citizens in your local community who would find it helpful to know about and act on these reasons.

SECTION 3: Extend your thoughts and your actions as to what is worth knowing and doing as a citizen around places on the electrified rail network

Looking in a new way
These activities provide opportunities for students to extend their connected ideas about place and the electrified rail network.

Learning intention: Take action to help citizens use [measurement, shape, position and/or orientation] to keep safe on the electrified rail network. [extended abstract]

Differentiated success criteria: We will know we have achieved this because …

Multistructural	*I have helped create a resource to help people keep safe around places on the electrified rail network*
Relational	*… and I explain how and why the ideas in the resource will help people keep safe around places on the electrified rail network*
Extended abstract	*… and I seek and act on feedback to improve ideas in the resource that will help people keep safe around the electrified rail network.*

Key Competency self-assessment rubric[3] Highlight the relevant Key Competencies for section 3.

Thinking	**Managing self**	**Participating and contributing**	**Relating to others**	**Using language, symbols and text**
Critically analyse the factors contributing to safe electrified rail networks for all citizens. *Example – describe, explain and justify ways to stay safe at places on the electrified rail network.*	Act responsibly when around the electrified rail network as a pedestrian, passenger, cyclist or driver to ensure all citizens keep safe. *Example – adopt a "sort it and report it" approach to unsafe behaviour around the electrified rail network.*	Display an awareness of the local issues around creating and maintaining safe electrified rail networks. Be actively involved in community issues around safe electrified rail networks. *Example – listen, respond and act together to make the electrified rail network a system free of death and serious injury.*	Interact with others to create safe electrified rail networks. *Example – demonstrate a commitment to safer outcomes for self, friends, family and whānau at places on the electrified rail network.*	Interpret and use language, symbols and text in ways that keep citizens safe around electrified rail networks. *Example – share safe rules and behaviours for places on the electrified rail network.*

[3] For draft versions of these Key Competency self-assessment rubrics, see the appendix.

3.0. Create a resource or an action to help citizens in your community to keep safe on the electrified rail network

Use measurement, shape, position and/or orientation as a context for communicating these key messages:

- **Stay away from overhead wires carrying electrical energy.**
  - *The electrical energy that moves trains is always dangerous and always on.*
  - *You cannot hear, see or smell electrical energy.*
  - *The electrical energy is 100 times more powerful than the electrical energy used at home.*
  - *The electrical energy can jump gaps of up to 3 metres.*
  - *When electrical energy passes through people, it kills or seriously injures them.*

- **Always use level crossings to get across the tracks.**
  - *Trains on the tracks are very big, very fast and very quiet.*
  - *Trains take a long time to stop.*
  - *It is dangerous to take shortcuts and trespass.*

- **Watch out for the second train.**
  - *Obey all warning signs and signals.*
  - *Wait until all warning signs have stopped before crossing – there may be a second train.*
  - *Look and listen in both directions.*

Identify a group of citizens in your community who need help to be safe around the electrified rail network.

Plan and create a resource, message or action using measurement, shape, position and/or orientation to help the group keep safe around the electrified rail network.

Use your learning from sections 1 and 2 to plan an infographic, brochure, rail network map, creative remix, billboard advertisement, cartoon, comic strip, picture book, game, activity or TV advertisement, street performance, signage etc. with an important mathematical message about citizenship and keeping safe on the electrified rail network.

Before you start, look at examples of how others have used the language of mathematicians to keep citizens safe. Search for measurement- and orientation-based safety infographics and advertisements etc. on Google Images and YouTube.

Use the findings from your research above to identify an important "keep safe around the electrified rail network using active citizenship" mathematical message for your resource, message or action.

Create your resource, message or action.

Seek feedback on its effectiveness with your target audience.

Present the resource, message or action to young people in your local community and the people who look out for them – for example, students at your school, whānau, parents, local business owners and/or local body politicians.