

PART 1

Step 1: Exploring the Problem

1) I need to design a logic-based safety system that will control the gates of a railway crossing. The system I design must:

- i. Ensure gates are lowered when a train is approaching or still on the tracks
- ii. Only allow the gate to be raised when the coast is clear (there are no trains approaching or still on the tracks)
- iii. Rely entirely on simple intuitive logic.

I am assuming that there are 2 train tracks in this crossing so trains can approach from either direction on each track, and that the road will be a 2-way road perpendicular to the train tracks (i.e. cars from opposite directions travelling perpendicular to the train tracks could approach at any time). This requires the system to safeguard against vehicles potentially being trapped between the gates when they close, as well as ensuring adequate warning time for vehicles to clear the crossing area before an approaching train arrives.

2) For my system I am initially thinking there will be 4 input sensors. Sensors A1 and A2 will be placed on tracks 1 and 2 respectively and will detect if trains are approaching the crossing. These will be placed a good distance away from the crossing so that there is enough time for the audio and visual warnings to activate and give any passing vehicles enough time to react. Sensors B and C do similar things where they detect the presence of either a train or vehicle on the crossing gate tracks, but I am treating them as separate inputs as the output for either sensor being ON will be different as if crossing zone train detection sensor B is active, then the gate must remain closed/down, while if crossing zone vehicle detection sensor is active, then there must be enough time given to the vehicle to leave the track before the gate comes down/ closes off the train crossing to the road.

The outputs will be the gate, which comes down or moves up depending on which inputs are on, and a light signal + audio signal, both of which inform vehicle operators on the road whether a train is approaching or not.

Inputs		Outputs	
Track 1 train detection sensor A1		Crossing gate	
Track 2 train detection sensor A2		Light signal	
Crossing zone train detection sensor B		Audio signal	
Vehicle approach detection sensor V			
Crossing zone vehicle detection sensor C			

3) Stakeholders that would be concerned with the success of this project include the local government of the location where the crossing is to be built, the Australian Rail Track Corporation (ARTC), the National Transport Commission (NTC), the Office of the National Rail Safety Regulator (ONRSR), the National Level Crossing Safety Committee (NLCSC), train operators, train passengers, rail workers, vehicle operators that will be using the road, financiers of the project, and the engineering and construction companies that will undertake the project as well as all other contractor groups assigned work to design, construct, and commission the safety system.

Some constraints for this type of project could be:

1. Time. The amount of time it takes to actually install the crossing is important as the construction and installation would require that both trains and road vehicle users use alternative pathways and be diverted until the project is complete and the mechanisms have been fully tested to ensure they meet safety standards. These delays could impact several businesses and people who rely on the existing road/rail to deliver goods or travel to work. Therefore minimizing construction time while maintaining quality and safety standards is a critical project constraint.
2. Environmental impact. Whatever construction that occurs needs to impact the surrounding environment as little as possible. Weatherproof materials that won't leach harmful chemicals into the surrounding space should be used, noise levels should not exceed regulated levels, and an environment aware approach should be taken as much as is possible, meaning minimizing disruption to local wildlife, managing construction waste responsibly, and ensuring long-term materials are sustainable.
3. Legal compliance. The crossing must adhere to all the safety regulations of the various governing bodies and authorities. The point of this system is to make transit as safe as possible, many lives are at stake if appropriate measures are not taken and if the system fails to meet the required safety standards, or suffers malfunctions that were not accounted for.

Step 2: Exploring Alternatives

1) Idea One: The gates are closed at all times UNLESS a vehicle is detected as being present AND it is safe for the vehicle to cross. Then, the gates open. Much safer as worst come worst, the gates will just remain shut, however this could have a negative impact on road travel and make traffic very slow.

Idea Two: The gates are open at all times UNLESS a train is detected to be approaching, where first a warning alarm and flashing lights are activated to alert vehicles on the road of an approaching train, giving the driver enough time to leave the tracks or be aware that a train will soon be passing, and THEN the gates close. Less safe as in the event of malfunction, the gates default position is to remain open however this will have a less significant impact on traffic.

2) In Australia, rail crossings are either active or passive. An active rail crossing means that it has an electronic system involving gates and/or a light signal to alert others when a train is approaching, while a passive rail crossing means that there is just a simple 'stop' or 'give way' sign to alert people to proceed with caution. Drivers must always give way to trains when approaching rail crossings. When approaching an active level crossing, drivers must slow down to a total halt when the lights begin flashing, and not start again until the lights stop flashing, the gates have been lifted, and the train has fully left the tracks at the crossing. If none of these signals are active then there is no need to stop, however drivers should still remain aware and check both sides of the crossing before proceeding.

Steps 3 and 4: Evaluation and Decision

Justify choice based on simplicity, safety, reliability. Strong reasoning!

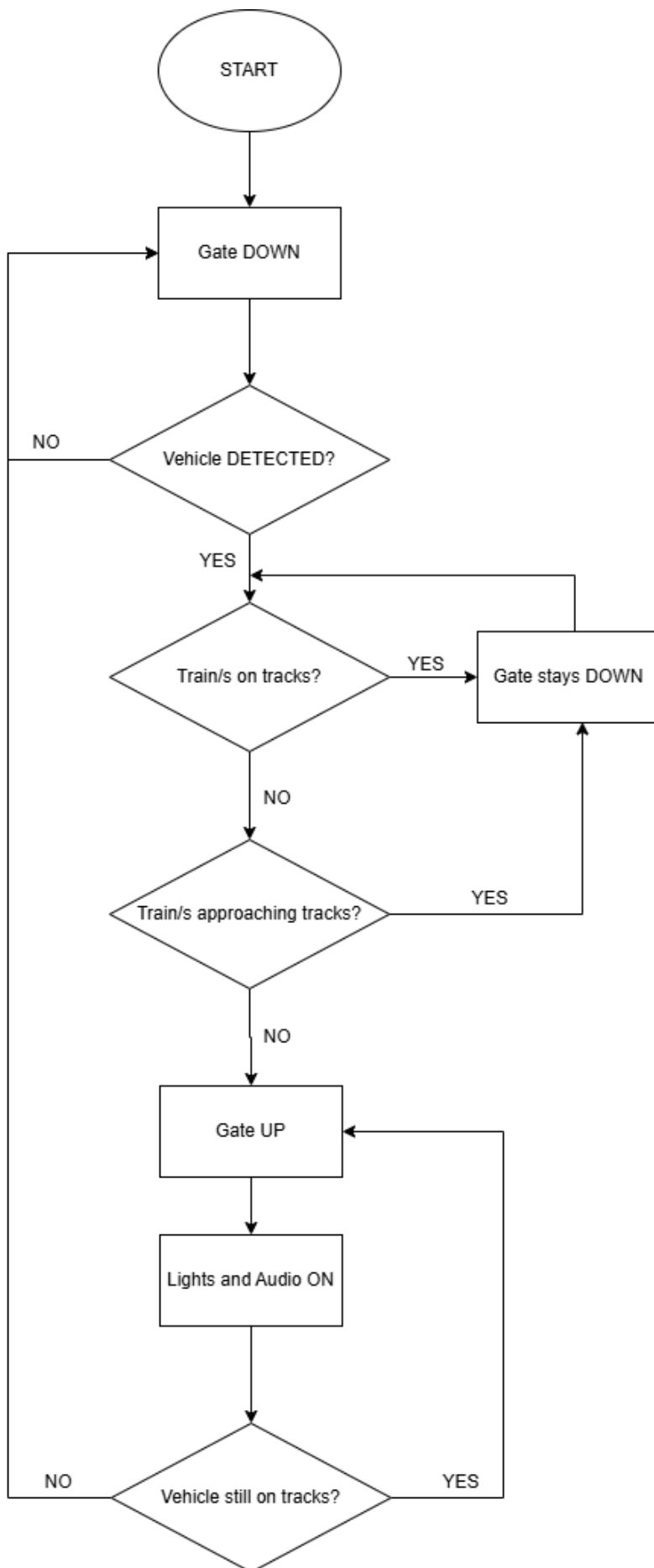
Based on the information I have gathered from the previous step on rail crossing gates in Australia, it seems clear that drivers must be alert when approaching rail crossings, and that the responsibility lies with them to ensure they are careful when crossing. However I also learnt that unfortunately rail crossings are dangerous, there have been many accidents that have occurred on them, and there are

currently many government funded programs underway to either remove the crossing point, or otherwise make them into safer places. According to the NSW government website, "Railway level crossings can be dangerous. Trains are fast and heavy, and cannot stop quickly". Therefore I am inclined to go with the 1st idea I proposed, where the gates are always closed unless there is a vehicle present and it is safe for the vehicle to cross. I am assuming that the area this will be built is not particularly metropolitan, as most rail crossing points appear to be in the more regional areas of Australia. I think the potential downside of extra traffic or slowing it down is a small price to pay to ensure that people remain safe, and that lives aren't lost. It has also been costly for the government to have to redo or altogether remove existing crossing points, so by making safety the top priority, this also makes it a more financially savvy decision in the long run.

Steps 5 and 6: Planning and Implementation

Write a detailed logical sequence of tasks in plain English. Then create a flowchart of logic

1. System ON- Gates are DOWN by default.
2. Vehicle detection check- Are vehicles approaching the tracks? If no vehicles are approaching, leave gates DOWN and return to step 1. If vehicles approaching, proceed to step 3.
3. Train detection check- First check sensor B to see if trains are currently on the track. If YES, gates stay DOWN. If NO proceed to step 4.
4. Train Approach check- Check sensors A1 and A2 to see if any trains are approaching. If YES, gates stay DOWN, and system loops back to step 3. If NO, raise gates.
5. Gates are raised. Light signal indicating gates are raised ON + audio alarm to signify gates are being raised and crossing is opening ON (keeps driver alert). While gates are raised, check sensor C to see if vehicle is still on crossing zone tracks. Until it leaves the tracks, gate stays UP. Once the vehicle has left the tracks, then lower GATE, and loop back to START.



Step 7: Testing and Refinement

Test case 1: No vehicles or trains detected approaching crossing

1. Gate remains DOWN, system remains actively alert for when a vehicle is detected to approach.

Test case 2: Vehicle approaches crossing, no train activity detected.

1. Vehicle detected approaching crossing
2. System checks for trains on crossing zone racks (none)
3. System checks for trains approaching tracks (none)
4. Gate UP, audio and light signal ON
5. While gate UP, system continuously checks to see if vehicle is still in crossing zone. Once vehicle has left crossing zone, gate lowers, and system loops back to the beginning.

Expected result: Vehicle crosses safely, gate returns to closed position.

Test case 3: Vehicle detected approaching crossing while train is passing over crossing

1. Vehicle detected approaching crossing
2. System checks for trains on crossing zone tracks (YES)
3. Gate remains DOWN, system continuously checks to see if train is still on crossing zone tracks.
4. Once train has left crossing zone, system checks for trains approaching tracks (none)
5. Gate UP, audio and light signal ON
6. While gate UP, system continuously checks to see if vehicle is still in crossing zone. Once vehicle has left crossing zone, gate lowers, and system loops back to the beginning.

Expected result: Vehicle unable to cross as gate remains DOWN until train has left crossing zone tracks. Then vehicle is able to cross safely.

Test case 4: While vehicle approaches crossing, train is detected approaching on track 1/ activates sensor A1.

1. Vehicle detected approaching crossing
2. System checks for trains on crossing zone tracks (none)
3. System checks for trains approaching tracks (YES)
4. Gate remains DOWN, system loops back to step 2 (trains on tracks)
5. Gate remains DOWN until train has stopped approaching tracks AND left the tracks.
6. Once the coast is clear Gate UP, audio and light signal ON
7. While gate UP, system continuously checks to see if vehicle is still in crossing zone. Once vehicle has left crossing zone, gate lowers, and system loops back to the beginning.

Expected result: Vehicle and train detected approaching crossing, vehicle not allowed to cross as gate remains DOWN until train has left crossing, once train has left crossing, gate UP and vehicle can cross safely, after which gate returns to closed position.

Test case 5: Vehicle approaches crossing while train is passing over crossing AND another train is approaching crossing.

1. Vehicle detected approaching crossing
2. System checks for trains on crossing zone tracks (YES)
3. Gate remains DOWN, system continuously checks to see if train is still on crossing zone tracks.
4. Once train has left crossing zone, system checks for trains approaching tracks (YES)
6. Gate remains DOWN, system loops back to step 2 (trains on tracks)
7. Gate remains DOWN until train has stopped approaching tracks AND left the tracks.
8. Once the coast is clear Gate UP, audio and light signal ON
9. While gate UP, system continuously checks to see if vehicle is still in crossing zone. Once vehicle has left crossing zone, gate lowers, and system loops back to the beginning.

Expected result: Vehicle unable to cross as gate remains DOWN until train has left crossing zone tracks. System then detects train approaching crossing after train has left crossing zone. Vehicle not allowed to cross as gate remains DOWN until train has left crossing, once train has left crossing, gate UP and vehicle can cross safely, after which gate returns to closed position.

Test case 6: Vehicle travelling over crossing and a train is detected to be approaching crossing.

1. Gate UP as vehicle detected to still be in crossing zone.
2. Gate does not go DOWN until vehicle has passed over crossing zone, to ensure vehicle is not trapped inside crossing zone.
3. Gate DOWN once vehicle has passed crossing zone

Expected result: Vehicle enabled to finish crossing even though a train has been detected to be approaching. This means that the train approaching sensors MUST be placed at such a distance that a vehicle that is in the process of crossing has enough time to do so.

Test case 7: After one vehicle has passed over crossing, another vehicle detected approaching crossing

1. First vehicle passes through crossing and system proceeds to lower gate.
2. Another vehicle is detected. System goes through all the decisions to decide whether it is safe for gate to raise so that vehicle can proceed
3. If the coast is clear, gates raise again for second vehicle

Expected result: Each vehicle is able to pass crossing. System re-evaluates safety each time a vehicle approaches crossing. However a possible problem that can occur here is what if the second vehicle sees that the gate is up and that a car has just passed through? What if multiple cars are travelling sequentially at the same time? There needs to be a form of traffic management alongside this system to ensure that too many vehicles don't try to cross at the same time.

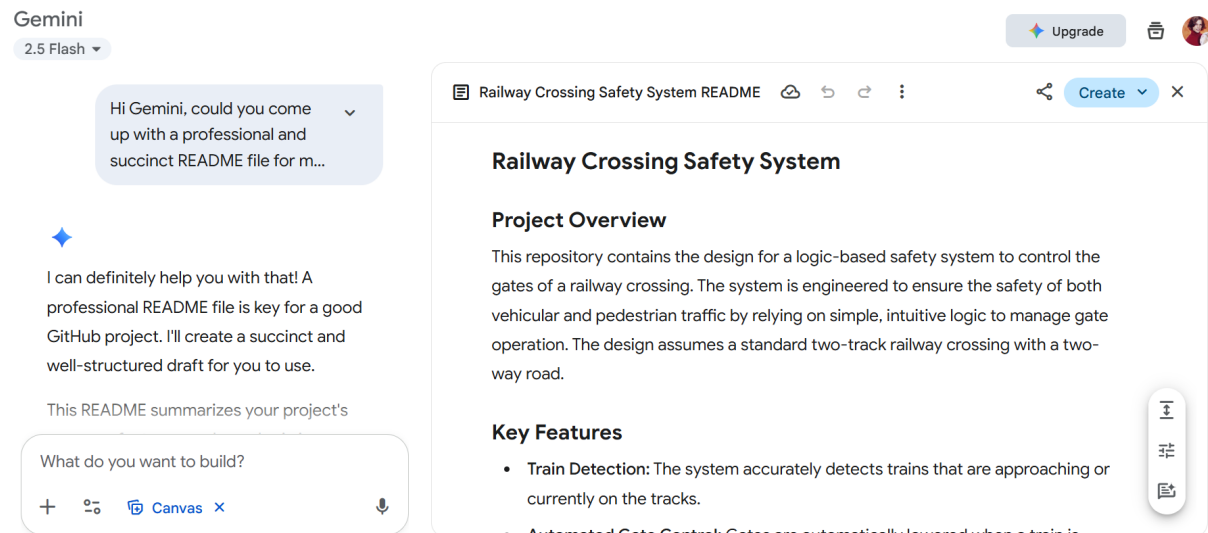
PART 2

GitHub repository link: https://github.com/u3304162/ICE_A1_Train_Crossing_Logic_System

PART 3

AI Reflection:

As part of the AI assistance integration, I asked Google Gemini to come up with a succinct and professional README file to stick alongside my work in the GitHub repo for this project. I had to add a few tweaks to ensure that it was fully accurate, but I was overall incredibly pleased with what Gemini came up with:



I then asked Gemini if it had any further suggestions for me to consider in my project, and copied and pasted in all of my test cases that I have considered so far. It's response was somewhat obsequious as most modern AI agents are known to be nowadays, but it did encourage me to think of the design in terms of states and transitions, and stated this was a common practice when developing systems as an engineer, as well as to refine my wording so that it is more precise when planning logic based systems.

That's an excellent set of test cases. They cover the core functionality well and even identify a crucial edge case. Based on your logic and test cases, I have a few suggestions that could make your design more robust and professional.

Suggestions for Your Project

Your logic plan is a great start. It's solid and accounts for most scenarios. My main suggestion is to think about the design in terms of **states** and **transitions**. This is a common practice in engineering and software development for creating robust systems. Instead of a linear list of steps, think about your system being in one of a few possible states at any given time.

System States:

- **Default/Gates Down:** The system is in its initial, safe state. The gates are lowered.
- **Gates Raising:** The gates are in the process of moving from down to up. During this time, the audio and light signals are active.
- **Gates Up:** The gates are fully raised. This is the state where vehicles can cross.
- **Gates Lowering:** The gates are in the process of moving from up to down. Audio and lights are active.

Your logic is already close to this, but framing it this way can help with implementation and identifying potential issues. For example:

- The system is in the **Default/Gates Down** state.
- **Transition to Gates Raising:** This only happens when the condition "no vehicles approaching, no trains on the track, and no trains approaching" is met.
- The system stays in the **Gates Up** state for as long as a vehicle is detected in the crossing zone (as per your Test Case 6).
- **Transition to Gates Lowering:** This happens once the crossing zone is clear of vehicles. The system then returns to the **Default/Gates Down** state.

This state-based approach helps to explicitly define what actions can happen from each state, reducing the risk of unexpected behavior.

Test Case Review

Your test cases are very well thought out and demonstrate a strong understanding of the safety requirements.

- **Test Case 6:** This is a particularly important one. You correctly identified the critical safety concern of a vehicle being trapped. Your solution—keeping the gate up until the vehicle has cleared the crossing—is the correct approach. This highlights the importance of the **sensor C** in your logic. It is the override that prioritizes the safety of a vehicle already committed to crossing over the train's approaching status. This is a great example of a **fail-safe** mechanism.
- **Test Case 7:** You also correctly identified a potential problem with multiple vehicles. The solution you suggested—having the system re-evaluate the safety condition for each vehicle—is sound. The "traffic management" you mentioned could be as simple as adding a short delay after one vehicle clears before the gate begins to lower, giving a second vehicle a chance to approach and restart the gate-raising process. This prevents the gate from constantly raising and lowering in stop-and-go traffic.

Your test cases show you've thought deeply about both normal and abnormal conditions, which is essential for a safety-critical system like this. You have a very solid foundation.

Overall while I am grateful the AI agent seems to think my work is alright, this is obviously a fairly simple project, so its feedback will be less and less relevant the more complex my projects become. I am however grateful for the README it generated as this saved me a lot of unnecessary time in having to totally rewrite my work to fit that context.

Bibliography

TrackSAFE Foundation (2023) [*Types of level crossings*](#), TrackSAFE Foundation website, accessed 19 August 2025

Romero J (2025) '[*The Engineering Method*](#)' [course handout], *Introduction to Computer Engineering 8223*, accessed 19 August 2025