Exploring Alternatives

❖ Different logic-based solutions

➢ Time-Phased zone protection

- **Working mechanism**
  - **3 different detection sensors are set at a distance of (500,200,50) meters which alerts the system of the arrival of the train.**
  - **Where if a vehicle is on track (v=1), which alerts the train to slow down using a red led, if there is no vehicle on track (v=0), which closes the gates and alerts the train that it is ok using a green led.**
  - **Once the train detection sensors are clear for more than 10 seconds the gates open.**

- **Advantages**
  - **Progressive warning system gives drivers more reaction time.**
  - **Reduces sudden gate movements that could startle drivers.**
  - **Allow partial closures for slower trains.**

- **Disadvantages**
  - **Requires more sophisticated sensor placements.**
  - **Higher installation and maintenance cost.**

➢ Traffic-Adaptive dynamic timing

- **Working mechanism**
  - **Camera with detection software is kept facing towards the 2 sides of the road.**
  - **3 different detection sensors are set at a distance of (500,200,50) meters which alerts the system of the arrival of the train.**

- **If the train approaches 200 meters, the gates start to close however if a car is stuck on the track one gate is closed to prevent other cars from coming and the other gate is opened for the car to move off the track after which the gate closes.**
- **Once the train detection sensors are clear for more than 10 seconds the gates open.**

▪ Advantages

- **Optimizes both safety and traffic flow.**
- **Reduces road congestion.**
- **Responsive to actual conditions.**

▪ Disadvantages

- **Requires additional infrastructure.**
- **More complex control algorithms.**
- **Potential synchronization challenges.**

➢ Basic safety-first logic system

▪ Working mechanism

- **Gates close immediately when any sensor detects a train or obstacle.**
- **Gates only open after 60 seconds of complete clear signals.**
- **No exceptions or special cases**

▪ Advantages

- **Extremely reliable - always errs on the side of safety.**
- **Simple to implement and maintain.**
- **Works with minimal sensors.**
- **Low cost**

▪ Disadvantages

- **May cause unnecessary gate closures (false alarms).**
- **Fixed timing can delay traffic unnecessarily.**
- **Doesn't account for train speed/distance.**

➢ Smart adaptive logic

- **Working mechanism**
  - **Calculates train speed to time gate closure perfectly.**
  - **Adjusts based on time of day (more caution during rush hour).**
  - **Learn's from past crossings to optimize timing.**

- **Advantages**
  - **Reduces traffic delays with better timing,**
  - **Can handle complex crossing situations.**
  - **More efficient operation over time.**

- **Disadvantage**
  - **More expensive sensors required.**
  - **More complex programming.**
  - **Needs regular calibration.**

➢ Real world example

- **Siemens' *SICAT* crossing control system is widely used in Europe and globally. It combines track sensors, obstacle detection (LiDAR/cameras), and predictive algorithms to automate gates. Key features:**
  - **Uses axle counters to detect trains approaching up to 5 km away.**
  - **Obstacle detection keeps gates during power failures.**
  - **Integrates with railway signaling systems for synchronized operations.**

- **Deployed in high-speed (Germany's ICE) and urban networks, SICAT reduces accidents while optimizing traffic flow. Its modular design allows customization for different rail environments.**