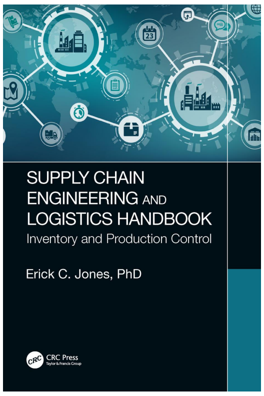

Supply Chain Engineering and Logistics Handbook
Inventory and Production Control
Erick C. Jones

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Publication details
https://test.routledgehandbooks.com/doi/10.1201/9781315159096-22
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Published online on: 05 Dec 2019

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Railroad Car Tracking by an RFID System to Organize Traffic Flow

Erick C. Jones, Mehmet Eren, and James R. Bubbels

There is one quality which one must possess to win, and that is definiteness of purpose, the knowledge of what one wants, and a burning desire to possess it.

Napolean Hill

22.1 Introduction

Almost every driver who has come across a railroad crossing and has had to wait for the train to pass has probably wondered to themselves: what if they had been warned of the oncoming train? If they had known about it blocking their path, would they have gone another way? Since not every railroad crossing has an overpass to allow traffic to freely pass, traffic can get backed up during busy times causing potential delays. With a warning system somewhere along their route, drivers will be able to take alternate routes and potentially save time.

Several issues can result from a traffic buildup with safety being the largest. The Southwest Research Institute recently presented the Texas Department of Transportation TransGuide with a system design document that looked right into the heart of the subject matter. The system is called AWARD or **A**dvance **W**arning to **A**void **R**ailroad **D**elays. This system would notify oncoming traffic of an oncoming train and that they would need to take an alternate route to avoid this train or expect a delay waiting for the train to pass.

The system, however, does not use radio frequency identification (RFID) as a tool.

RFID has been around for a long time, but until recently, it has not been really been utilized as well as it could potentially be. The RFID Certification Handbook[1] not only talks about RFID in general, but also gives insight as to where it could and already is used. An RFID system consists of a tag (either passive or active), reader, antenna, edgeware, middleware, and some sort of IT system. The RFID system can be set up to desired settings if the appropriate components are being used. In this particular case, the RFID system can be used not only to set up a warning system for oncoming traffic, but also to tell what the train is carrying, where it has been, and even how fast the train is currently traveling. This is why it would be interesting to see if an RFID system would potentially work in this particular situation. Information is invaluable to every component of a supply chain, and RFID could potentially provide it readily and in real time.

Another aspect that needs some attention in this project is the traffic signalization and specifics regarding what can be done at an intersection or section of railroad. The book, *Traffic Engineering*,[2] goes into these specifics. Although the specifics are not in great detail, they certainly are very helpful when tackling this particular task. The signalization times, design standards and regulations, and basic ideas to help create an ideal warning system are listed in this book.

When it comes to ideas on how to communicate with the drivers of the vehicles, the book *Intelligent Transportation Primer*[3] has a lot of good ideas. There is everything from a simple LCD display sign

[1] Harold and Jones 2006.
[2] Roess, Prassas, and McShane 2004.
[3] The Institute of Transportation Engineers 2000.

strategically located along the route, to simply having the driver tune his or her radio to a particular radio station which updates them with the information they need to know. Although there are many options, RFID may limit the ones that can be used and the ones cannot be used.

In the article *Safety Warning Based on Highway Sensor Networks*,[4] the authors go on to talk about a proposed system in which various sensors would be used to record and send information to inform drivers of what is happening ahead. They go on to say how and when a driver should be warned. Their proposed system is not limited to only railroad crossings, but can also be utilized for any traffic problem. The whole concept behind this system is not only safety but to also eliminate any unnecessary delays.

22.1.1 Current Problem

Railroad crossings cause delays in traffic. In most places, an approaching train cannot be seen from a far enough distance that drivers are able choose an alternative route. Instead, they head to the crossing and are forced to wait. In many situations, cars get trapped with no way out.

Freight trains generally have more cars and are much longer than passenger trains. Their speed tends to also be relatively low. They are the biggest part of the train network in the United States. Most freight trains have 100 cars on average, and each car is 51.51 ft (15.70 m). For safety purposes and certain laws, trains lower their speed when they get close to a crossing which creates longer times for the cars to wait at the crossing. The average passing time through a crossing for freight trains is about 4.5 min. In some crossings, this time can be up to 12 min due to weather and conditions of the trains.

Many railroad crossing accidents are caused by the cars and pedestrians who get to a closed railroad gate and do not obey the traffic signalization for various reasons. Nearly half of the total crossing accidents are caused at the railroad crossings which have warning devices like the stop signs, advance warning signs, and pavement markings. Many of these accidents occur when the lighting is poor and the people cannot visually see the train coming or they simply misjudge its location. Even with many new devices and methods being tested, accidents are still regularly occurring and a need for a new system is evident.

22.1.2 Reason for Improvement

The objective of the proposed system is to provide a warning system to traffic and prevent unnecessary delays. RFID can be used in place of other proposed systems, such as using radar sensors and underground sensors. These systems do not allow for flexibility and sometimes do not provide accurate information to the control center. Radar systems tend to be sensitive to the environment. Very cold weather or heavy rain can alter its functionality.

RFID eliminates this issue and provides extended information to the control center. This allows them to organize the traffic flow more efficiently. In doing this, not only does it organize traffic, but it also eliminates the unwanted backups at the crossings.

Another possibility, besides being a tool in a warning system, RFID may also be used for nationwide railcar tracking network to follow the movement of any train equipped with RFID system. There is also a possibility to use RFID for tracking passenger trains and for providing their expected arrivals–departures. This information can be updated on Internet, so the people who are going to use the train will be informed by using the website.

Being able to track railcars in real time opens the door to better supply chain management. Information about the location of supplies or finished goods could potentially speed up the entire production process and provide better customer service. This concept is not limited to only railcar tracking. It can also be applied to trucks, airplanes, and any other means of transporting goods.

The RFID tracking systems, like every system, have pluses and minuses. When all these are taking into consideration, RFID comes out on top as a great tool to solve the problem of traffic backups considering its other potential uses.

[4] Xing, Ding, Cheng, and Rotenstreich 2005.

22.1.3 Strategy

The proposed RFID system would use active tags to send and record any necessary information. The rest of the RFID system would need to be task oriented and specific.

The reader which reads the signal of the active tag mounted on the train needs to send the tag data to traffic signal control center. This task could be accomplished in a few different ways. First, a copper-twisted pair cable line can be used to connect the reader to the control center. By using the cable, the cost would be more reasonable in the long term, in comparison to other methods. Also, communication cutoffs would be minimized due to the cable's reliability. However, this method requires setting the cable underground which would take a lot of time, and it does not provide any flexibility for any kind of system changes if some conflict would arise.

Another possible method of communicating with the control center to consider is using a wireless technology. Bluetooth 802.11 technology is a wireless technology that connects the electronic devices wirelessly. Low required power can allow using sunlight as energy source for this method, but because of current distance limitations of the Bluetooth 802.11 technology, it would not be suitable for this application.

This leads to another possibility, a Global Positioning System (GPS). The current space-based telecommunications environment is characterized by satellites orbiting the earth at various distances. The signals can be transmitted and received with GPS devices by using the satellites. This kind of communication is expensive, and it requires the user to be registered in the network all the time. This potentially rules GPS out as an option for the final system design.

The final option is broadcasting the signal from the reader to the control center. A radio station uses a small portion of the radio spectrum for broadcasting audible data. Radio data systems use a portion of the unused spectrum called a subcarrier to transmit information. An radio data systems (RDS) receiver receives the signal and then decodes it, or translates the information to text or audio information. This makes broadcasting a feasible option for the proposed system.

22.2 Methodology

22.2.1 Testing the Active Tags

The experiment consisted of a RF Code Mobile Reader installed in a HP Palm Pilot, RF Code active tags with a frequency of 303 MHz, and a car. The idea was to test the reader's ability to read while the tags were in motion much like a train would be. If the tags read consistently, then the system would be feasible. The test consisted of five active tags placed on the car at selected locations. Then, the car would drive past the stationary reader, and the data could be recorded for various speeds of the car.

22.2.2 Test Results

The car was tested at speeds of 0, 10, 20, 30, 40, and 50 miles/h. Each time the reader would capture certain tags based upon their location and also the speed of the car. The tag placed on the nose of the car proved to be the only tag that read every single time. The tags placed on other locations read based on the speed. The tags were numbered 1 through 5 with Tag 1 being the tag on the nose of the car. Tags 2, 3, and 4 were placed on the car's windshield, and Tag 5 was located inside the car. Since there was always one tag reading every single test, it can be concluded that speed is not a factor and that using active tags in the system is feasible.

22.2.3 Finding a Practical Way to Send Data to the Control Center

As mentioned before, each RFID reader placed around the crossings needs to communicate with the traffic control center. This can be established by wire or wireless communication. In the case of placing the readers around the crossing and assuming the traffic control center is to be not more than 4 miles away from the reader location, a radio transmitter or radio modem would be a good solution. The fact that the readers are placed outside and they communicate with the control center in open environment with no line of sight requirement makes the process easier. The frequency of 458 MHz allows a communication range up to 20 km in free space. A transmitter and receiver with that frequency are recommended to connect the RFID to the control center.

22.2.4 Determining the Appropriate Layout to Set the Devices

Since the connection from the reader to the control center can be made wirelessly, a certain tolerance for the distance of placing the readers must be considered. This tolerance allows the control center to organize the routes properly for specific cases. For the proposed system, RFID readers are to be placed about 1.5 miles away from the crossing.

22.3 Simulation Results

To demonstrate a case regarding the wait time of the cars, SIMUL8 software is used. In the simulation,

4,000 unit = 1 min
66.667 unit = 1 s
Average passing time for a train = 5 min[5] (default)
Train speed = 30 mph (default)
Average wait time for a car due to closed crossing = 3.8 min
Average number of cars waiting = 73.6

From this result, each car loses 3.8 min depending on the time of the day, and there are approximately 74 cars involved this loss. Therefore, each time the crossing is closed, the average total time lost is 4.29 h. This might not represent any variable that can be used in the calculations, but it makes sense if some of the drivers are in duty and using their working time.

There are also some accidents which occur concerning railroad crossings. These accidents can be caused by signalization errors or the cars that do not obey the signalizations. An early warning system might be able to reduce these accidents. The idea is to divert traffic so that there are fewer backups. If traffic is diverted, there is less of a chance of an accident caused by a driver not being alert or impatient.

22.3.1 Cost Analysis

The essential equipment for an RFID system is the reader and a tag. As mentioned earlier, the recommended tags need to be active, which are more expensive than passive tags. The range for active tags is $35–$142. The tag that has the highest read range of 100 ft is about $140. Each train requires one of these active tags costing $140.

Because of the environment, the reader has to be durable, but at the same time, it should not be costly. There are many kinds of active readers in the market that cost anywhere between $1,200 and $7,000. The reader chosen for the proposed system costs $1,480.

If we look at the average total cost for a crossing including the other equipment required, the following are found:

The reader: $1,200–$7,000
Active tags: $35–$142
Transmitter – Receiver: $300–$800

[5] Based on the interview with Bhaven Naik, PhD std.- Mid America Transportation Dept.

Electronic sign: $80–$600
Labor: $700
Average total for the proposed system: $4,100 (two readers—tags not included)
Periodic cost: $350 each year (maintenance)
Total cost for 5 years: $5,850

If the system were to be implemented at every intersection not including tag cost,
280,000 crossings*$5,850 = $1,638,000,000

22.3.2 Recommendations

RFID readers can be connected up to four antennas. Taking advantage of this fact, instead of using a reader at each crossing, a reader antenna can be placed by itself at certain crossings. If two or three crossings are close enough to each other, only one reader would be necessary with the use of antennas. In this case, the communication can be established via special antenna cables which vary depending on the kind of the reader. This would in turn affect the cost analysis depending on what gets implemented.

An alternative solution could be to connect the reader directly to the traffic signs. This system would bypass the control center. Each warning sign in this case needs to have a radio transmitter to get the information from the reader directly. Despite a cheaper alternative, this solution would take away from some of the benefits that RFID could create.

22.4 Conclusion

A RFID-based system can replace existing sensor systems with affordable cost and more effectiveness. The proposed RFID system has capability of sending more information about the train other than basic data such as the trains speed. The main question before the experiment is can the readers read tags in motion. The test results show that active tags are able to be read when they are at twice the expected speed of a passing train at an intersection. This makes the usage of RFID in a system a reality. A radio transmitter for communication between the reader and control center or directly to the electronic signs is the ideal recommendation for the proposed RFID system.

The primary concern of this study is saving time and avoiding backups. However, there is the definite possibility that the proposed system may help to prevent accidents. The total cost for the proposed system per crossing is $5,850. The system could be paid for in several ways depending on who is using it. In terms of a warning system, if it can prevent accidents from happening or even save the right person time, the potential savings begin to add up. In terms of the other possibilities, if a train can be tracked in real time, then supply chain management becomes faster. Also RFID may be able to help increase passenger traffic on passenger trains if a person could check the train's status in real time. The possibilities are endless, and a warning system using RFID is only the beginning. The initial cost may be large, but the potential savings and usage help tip the scale back into the proposed systems favor.

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