# Automated Metro Train

**B. Sudha, Shreyanshu Shankar Pandey, Sanjeevkumar Raikod, Ekansh More, Sachin Bajpai**

***Abstract*: *With rapid improvement in technology most of the industries are updating to automated technology in order to decrease the workload on man today. Along with this it eliminates the chances of error which man makes seldom, decreases costing, and improves efficiency. Automated metro is one such option in today's world which can reduce the congestion in railway network caused by human error and also ensure efficient use of power and time. The prototype of the automated train will make use of the popular RFID technology to mark arrival of stations i.e. the RFID tags will be placed on the head of the train and readers will be placed near to stations so that whenever the train approaches the station, the station reader can read the train tag and mark the arrival of train which will then slow down the train and make it stop at the platform. It will have its core on Arduino Mega, it will be continuously tracked using GSM Module, IR modules installed on the doors will keep a track on the number of passengers and LCD display Unit will be installed in the train compartment to keep the passengers notified about the arrival and departure from a station. In case of any technical faults the control room will be immediately updated using the GSM Module and Emergency Breaks installed in the train will be applied, also smoke detectors will be installed to check any kind of short circuits or fire in the train. Should RFID fail in the worse conditions, a backup facility to stop the train will be cut off of electric supply in the railway track.***

***Keywords: Arduino, RFID, Smoke Sensor, Automated Metro; formatting; style; styling; insert (key words)***

## I. INTRODUCTION

This project is being developed to understand the technology used in the driverless metro train system which is mostly used by some other developed countries like Germany, Japan and France. It is expected to solve the problem of mass transportation as well as the high transportation cost in the metro train system. It also gives accurate timing control of the train station arrivals and departures. The operation of the driverless metro train is controlled by a central processor unit like Arduino controller, 8051 processor or PIC controllers. The train will be programmed to run on a predefined path which has fixed distance of stations and the speed of the train will also be predefined and it will be controlled by the motor driver IC[1]. The time stoppage of the train on the stations will also be predefined. The RFID sensors and RFID tags will be used for stopping of the train. The whole operation of the train will be controlled and performed by a controller so it does not require a driver or train attendant for the operation of the train.

This project will use Arduino mega as the main controller of the whole system. The operation and control of the train will be performed by the Arduino. The different operation or functions of the train will be carried out by fetching the programs in the Arduino by using the Arduino IDE software.

| Grade of Automation | Type of train operation | Setting train in motion | Stopping train | Door closure | Operation in event of Disruption |
|---|---|---|---|---|---|
| GoA 1 | ATP with driver | Driver | Driver | Driver | Driver |
| GoA 2 | ATP and ATO with driver | Automatic | Automatic | Driver | Driver |
| GoA 3 | Driverless | Automatic | Automatic | Train attendant | Train attendant |
| GoA 4 | UTO | Automatic | Automatic | Automatic | Automatic |

ATP - Automatic Train Protection   ATO - Automatic Train Operation

**Figure1.1 Comparison of the Driverless Metro Train System**

Some other additional features like LCD display to give messages to the passengers, GSM-based SMS facility to know the position or location of the train and give that information to the control center by SMS service, alarms to give indication to the passengers for LCD messages as well as for indication of door operation, automatic door control, passenger counting section by using IR modules, MQ2 smoke sensor, vibration sensor, emergency brake button will also be included in this prototype.

In the driverless metro train system, there are four types of Grades of Automation available as shown in Fig 1.1. All the grades are having different features[1].

GoA (Grades of Automation)-1 is having automatic train protection system. The driver is required for starting of the train as well as stopping of the train and also for the door operation and for operation in the event of the disruption.

GoA (Grades of Automation)-2 is having the automatic train protection and operation. The starting and stopping of the train are automatic but for door operation and for operation in the event of disruption driver is required.

GoA (Grades of Automation)-3 is called as the driverless operation of the train. In that, the starting and stopping of the train are fully automatic but for door operation and in the event of disruption train attendant is required.

GoA (Grades of Automation)-4 is called fully driverless train operation or also called as unattended train operation (UTO). Hence in this operation, all the functions of the train are carried out by automatically.

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So there is no requirement of driver or train attendant to perform operations of the train.

## II. LITERATURE REVIEW

### A. Arduino Mega

An Arduino is a microcontroller based platform containing an Atmel AVR microcontroller and usually providing a set of connectors in a standard pattern. The microcontroller is typically pre-programmed with a "boot loader" program that allows a program (called a "sketch") to be loaded into the microcontroller over a TTY serial connection (or virtual serial over USB connection) from a PC. Arduino also simplifies the process of working with microcontrollers, but it offers some advantage for teachers, students, and interested amateurs over other systems: Inexpensive - Arduino boards are relatively inexpensive compared to other microcontroller platforms. Cross-platform - The Arduino Software (IDE) runs on Windows, Macintosh OSX, and Linux operating systems. Most microcontroller systems are limited to Windows. Simple, clear programming environment - The Arduino Software (IDE) is easy-to-use for beginners, yet flexible enough for advanced users to take advantage of as well. Open source and extensible software - The Arduino software is published as open source tools, available for extension by experienced programmers.

### B. RF-ID (Radio Frequency Identification)

It uses electromagnetic fields to automatically identify and track tags attached to objects. The tags contain electronically-stored information. Passive tags collect energy from a nearby RFID reader's interrogating radio waves. Active tags have a local power source (such as a battery) and may operate hundreds of meters from the RFID reader. Unlike a barcode, the tag need not be within the line of sight of the reader, so it may be embedded in the tracked object. RFID is one method for Automatic Identification and Data Capture (AIDC). A radio-frequency identification system uses tags, or labels attached to the objects to be identified as shown in Fig 2.1. Two-way radio transmitter-receivers called interrogators or readers send a signal to the tag and read its response.
RFID tags can be passive, active or battery-assisted passive. An active tag has an on-board battery and periodically transmits its ID signal. A battery-assisted passive (BAP) has a small battery on board and is activated when in the presence of an RFID reader[2]. A passive tag is cheaper and smaller because it has no battery; instead, the tag uses the radio energy transmitted by the reader. However, to operate a passive tag, it must be illuminated with a power level roughly a thousand times stronger than for signal transmission. That makes a difference in interference and in exposure to radiation.


**Figure 2.1 RF-ID TAG**

## III. PROBLEM IDENTIFICATION AND OBJECTIVES

### A. Problem Identification

The following are the problems that are identified in driver oriented trains:

- Congestion in Rail Network - The rail network of India is currently operated manually, because of which there is a lot of congestion in the rail network. This congestion causes heavy traffic in the rail network which has adverse effects on the life of the commuters [2].
- Human Errors - The rail system today in India is operated manually i.e. by the people of the railway department. As humans have tendencies to makes mistakes, the operations of railways also gets hampered at times due to human mistakes which leads to catastrophic incidents.
- Delay in departure and arrival - Automated trains have a major advantage over manual trains as manual trains are more often running late because of delay in departure[3].
- Live tracking of the train - Accurate location of train is also possible in Automated Trains which gives the commuters a hassle free journey.

### B. Objectives

The objectives of Automated Metro Trains are as follows:

- Low Operation Costs.
- Increased Capacity and Reliability.
- Increased Flexibility

*1) Lower Power Operation Costs*

Due to the high level of automation, the initial cost of the DTO systems is much higher than the traditional metro systems as pointed out in. However, the staff reductions in DTO systems could result in a much lower management and training cost, especially with the increasing cost for labour. Meanwhile, the maintenance cost is also declined for the DTO systems. The total operation costs of the DTO systems will also decrease. In a study of European mainline railways, staff per train kilometres is identified to be an important determinant of cost inefficiency. Andreau and Ricart concluded that the availability and scheduling of train drivers is highly linked to the organizational efficiency of urban rail transit systems. So staff savings available from DTO systems are obvious. The Paris metro reported that the operation costs of DTO systems are 30% lower when compared with the conventional lines. In addition, the operator of DTO systems in Keolis stated that the operational cost saving is about 10% due to staff reductions. The operational experience of Copenhagen automated metro showed that there are no labour costs associated with incremental changes in the supply of capacity and the costs are limited to the effort needed to compile and introduce the new service plan, the consequent changes to energy, and equipment wear and tear levels. Furthermore, the passenger demand of metro systems increases with the increasing of train frequencies as stated in.

Hence, the ridership of DTO systems should increase if the trains are operated with half the length at twice the frequency, which may increase the traction energy cost in a certain level but without any additional driver cost. It is concluded in that the strategy that operates the same total car kilometres but with shorter trains and higher frequencies for DTO systems is demand-generative, minimizing traction energy consumption while providing better performance than a longer-train, lower-frequency solution.

*2) Increased Capacity and Reliability*

Capacity is increased by higher operational speeds and train frequencies provided by DTO systems, where the headway can be reduced to 75 s, even to 60 s. In addition, DTO systems can reduce the turnaround times at the terminus to enable higher frequency. Therefore, additional trains can be put into the system during the peak hours to transport passengers. Moreover, DTO systems can respond immediately to congestion, running more trains without the need for extra staff. In addition, the frequency of the trains can also be enhanced in the low-traffic hours, as more and shorter trains can be inserted in traffic without the need for operational staff. Shorter headways provided by DTO systems reduce the expected waiting times of passengers. Additionally, more frequent arrivals of trains at platforms also shorten the boarding and alighting process, which results in shorter dwell times. It is stated in that if the headway between trains is reduced by 42 s, then the dwell time is about 3% less. In addition, better regularity and consistency of station stop times are also enabled by the improvements in frequency for DTO systems, while human factors can create variability and small delays in GoA 2 and GoA 3 lines . The Paris Metro reported that after upgrading the traditional metro system of Line 1 to DTO system, the same level of service can be provided by fewer rolling stock units. Moreover, the removal of the driver cabins enhances the physical space for passengers, which added 6% to capacity for Paris Metro Line 1.Reliable and robust operation is significant for metro systems. As pointed in, DTO systems require trains to stop at any point if necessary, such as the evacuation of people in emergency circumstances and train malfunctions.

It is showed that the long-term unreliability can reduce the passenger demand and metro effectiveness. The increase in the level of automation enhances the reliability and robustness of urban rail transit systems. It is reported that 33% of 5-min delay incidents could be reduced by switching from manual to automatic operation, i.e., from GoA 1 to GoA 2 or above. There are several reasons that DTO systems could improve the reliability: (1) The adjustments of running times and dwell times can be more precise and comprehensive; (2) removal of drivers reduces the opportunities for incidents caused by human error; and (3) DTO system manages the operations in terms of seconds, and it can recognize a system disruption more promptly.

*3 ) Increased Flexibility*

Flexibility is identified as the key operational advantage of DTO systems by all automated metros. DTO system breaks the connection between train availability and staff availability, which means that trains can be more easily included in or removed from circulation based on the passenger demand [4]. This real-time adaption of capacity to passenger demand can provide the passengers with better service and keep the operation costs as lower as possible. For sporting or other special events, in an automated line as many trains as needed can be injected into the required part of the line with short headways in response to the peaks in demand. Moreover, only a short notice, e.g., like 1 h before the special events, is needed rather than 3 months to schedule trains for automated metros as stated in. The flexibility of DTO systems to increase capacity for passenger demand was demonstrated by the Vancouver Sky-Train during the Expo' 86 world's fair in its first year operation and during the Winter Olympics in February 2010.The flexibility of DTO systems makes variable train services possible during off-peak hours and at night to lower operational costs. DTO systems also make the 24/7 operations less constrained because the operation of trains is less dependent on staff availability [4]. Now, the Copenhagen metro has enabled the 24/7 operation.

## IV. BLOCK DIAGRAM AND METHODOLOGY

### A. Block Diagram

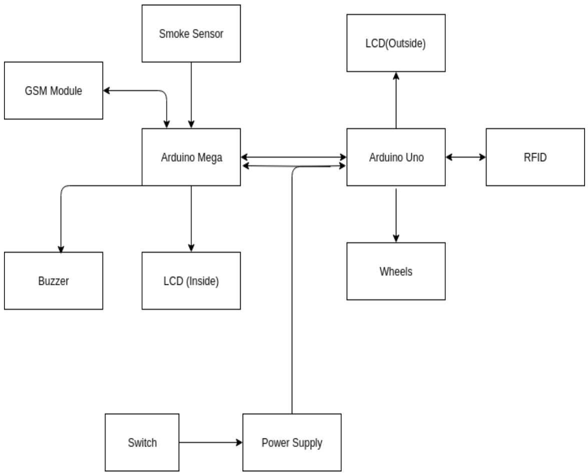


**Figure 4.1 Block Diagram of Automated Metro**

The block diagram of the Automated Metro prototype is given in Fig 4.1.

- Arduino Mega is the core of the prototype as all other components are connected to it and it controls the function of the prototype.
- RF-ID is the key of the prototype as it marks the arrival and departure of the train.
- L293D Motor Drivers are used to control the movement of the train and also the movement of the doors.
- IR (Infrared Modules) are used to count the number of passengers and GSM Module is used to contact the control room.
- Smoke Detectors and Vibration Sensors are included for security concerns.

### B. Methodology

The implementation model of the prototype is given in Fig 4.1.

- The prototype will have arduino mega as its main controller and will run through a 5v power supply.
- Initially when a train will be ready to move it will display the message "The train is departing in few
- minutes" in the LCD unit and a buzzer will be used as an alarm.
- Then the doors which are motor driven will close and also at that time itself using IR sensors the number of passengers in each section will be calculated.
- The train then starts moving. When the train will be approaching the next station the LCD unit will display the message "Train is arriving at the next station".
- Just before arriving at the next station RFID tags placed closed to the next station will be read by RFID readers placed on the train and the train will slow down and stop at the station Then the doors open and the cycle continues for every route. The timing between the stations will be set according to the speed of the train for smooth running. Using the GSM module, the control room keeps track of everything.
- In case of emergency the emergency brake will be applied and if RFID fails the electric supply will be cut off and the train will stop.

The SI unit for magnetic field strength *H* is A/m. However, if you wish to use units of T, either refer to magnetic flux density *B* or magnetic field strength symbolized as $\mu_0 H$. Use the center dot to separate compound units, e.g., "$A{\cdot}m^2$."

## V. RESULT

### A. Movement of Train Controlled By RFID

The primary outcome of the working model is achieved; the working model has the reader installed, so when it read the signals from the tag placed near the station, it stops at the station. The door then opens for a predefined time and then closes.


**Figure 5.1 Train Stopped at a Station**

The train then starts to move again and the cycle continues.

### B. Passenger Counting

The working of IR Sensor to detect the vacancy of seats is successful as the LCD Unit displays the seats which are full and the seats that are vacant as shown in Figure 5.2


**Figure 5.2 LCD displaying the vacancy of seats**

The situation when the train is filled to capacity is displayed as parking full by the LCD Unit as shown in Figure 5.3.


**Figure 5.3 LCD displaying all seats occupied**

## VI. CONCLUSION

The Automated metro train centred to the RFID system marked the arrival and departure of the train correctly and the doors opened and closed with the time delay mentioned in the code. The working model rightly reads the number of seats available in the train after arriving at every station and displays it in the LCD unit placed outside the train. The arrangements made for breakdowns such as fire was successful as the smoke sensor sensed the smoke and informed the control room using the GSM module. The Automated Metro Train can thus be the future of conventional metro trains providing an easy way to run the operations of passenger traffic. It creates a new opportunity for technical jobs and provides a hassle-free journey to the passengers.The errors caused by human mistake is also reduced to a large extent by the application the model.


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