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# THE INFLUENCE OF THE INTRODUCTION AND USE OF AGV$_S$ IN THE MANUFACTURING LINES

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**Rezumat:** *În această lucrare se va propune solutii de optimizare a fluxului de fabricație prin aprovizionarea zonelor de picking, utilizând noi mijloace de transport. În situația actuală, transportul cărucioarelor de piese este realizat prin intermediul unui tractor electric si se dorește eliminarea acestui tractor deoarece generează costuri atât în angajamentul operatorului ce transportă cărucioarele, cât și în timpul de funcționare al tractorului. În lucrare se prezintă rezultatele obținute pentru soluțiile de optimizare propuse, dar și comparații făcute între cele două mijloace de transport, tractorul electric și AGV, apoi este făcută o analiză a investițiilor și a costurilor.*

**Abstract:** *This paper will propose solutions to optimize the manufacturing flow by supplying the picking areas, using new means of transport. In the current situation, the transport of the forklifts is performed by means of an electric tractor and it is desired to eliminate this tractor 36-because it generates costs both in the commitment of the operator transporting the trolleys and in the running time of the tractor. In the paper, are presented the results obtained for the proposed optimization solutions, but also comparisons made between the two means of transport, the electric tractor and the AGV, and then it was done an analysis of investments and costs.*

**Keywords:** Logistics, Costs, Transport optimization, AGVs.

## 1. Introduction

Logistics encompasses the activities that manage product flows, coordinates the management of resources and deliveries, achieving a given level of service at low costs [1]. Logistics defines the wide range of activities required to achieve an efficient movement of finished products from the exit of the manufacturing process to the consumer and which, in some cases, includes the movement of raw materials from the supplier to the beginning into the manufacturing process. These activities include transporting products, warehousing, handling, protective packaging, stock control, choosing the location of factories and warehouses, order fulfillment, market forecasting and customer service [2].

The goal that governs all efforts in terms of the distribution network is to increase competitiveness.

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Increasing competitiveness and rapid changes in market conditions constrain many companies to optimize production or reorganize. [3]

Transport is the component activity of a logistics system, which ensures the connection between its different levels, from supply to distribution, on the route (Figure 1).


**Fig. 1.** Logistics system.

The elements of the route are often geographically separated by long distances. [4]

An automatic guided vehicle system is an advanced material transport and handling system. Automatically guided vehicle systems generally transfer to industry:

- semi-finished materials or workpieces in various stages of the manufacturing process, carried on pallets or in containers;
- subassemblies on their technological assembly flow.

The first AGV was built in 1953 by Barrett Electronics Corporation, and was designed and used as a modified tow truck, navigating from one point to another, following a wire from the field.[5]

*The advantages of Automatically Guided Vehicle systems are:*

- saving labor: human operators do not participate in domestic trucking, which leads to increased productivity;
- enhance the quality of products: less damages on transported objects than in the case of manual transport (human operators used for this purpose are usually unskilled);
- saving space: the long transfer made by AGVS being continuous, no more intermediate storage space, for creating reserve stocks to carry out the manufacturing activity between two transports, like a classic transport system internal;
- the concept allows the system to be easily adapted to the changing requirements of the other CIM components in the sense that the routes on which automatically guided vehicles travel are usually easily changeable;
- the system integrates the components of the production system from the point of view of the flow of materials, strengthening the unitary character of encompassing the components it connects in a single system;
- the system allows a very clear record of all the materials moving within the CIM hyper-system at a given time (similarly to ASRS);

- facilitates manufacturing in "clean rooms".

*The disadvantages of Automatically Guided Vehicle systems are:*

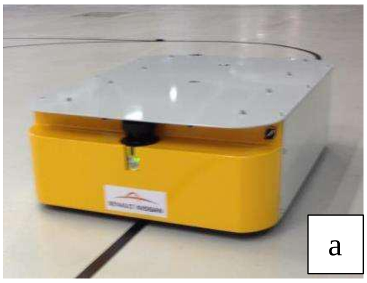
- high costs;
- new technical problems difficult to solve when operating vehicles outside buildings (vehicles do not operate in lower temperatures), or when switching from one hall to another;
- the terrain on which the vehicles circulate (hall floors, external access roads) must have a certain surface quality, no potholes, unevenness, no slopes greater than 10% and no obstacles on the routes;
- if the technological discipline is not enough developed, there is a danger of transforming vehicles into warehouses: instead of circulating, they become stationary tables, loaded with parts.

The automatic guided vehicle system is that unmanned transport system which is automatically controlled by its own drive mechanism. It is used in industrial environments, especially in logistics, distribution, production and warehousing. These cost-effective transport systems operate without the help of people and contribute to a high level of profitability in the operating process. [6]

## 2. Main features of AGV systems

An automatic guided vehicle system is an advanced material transport and handling system. Automatically guided vehicle systems generally transfer to industry: - materials as semi-finished products or processed parts in different phases of the technological flow of manufacturing, carried on pallets or in containers; - subassemblies on their technological assembly flow.

The main types of guidance (navigation) of AGV systems are: contour guidance, spot navigation, optical guidance, magnetic stripe guidance and laser navigation. Navigation using tapes (magnetic or colored), is presented in the Figure 2.




*a.* Automatically guided vehicle


*b.* AGV in the Assembly Department [7]

**Fig. 2.** Navigation using tapes.

In the practice applications of AGVs there is a need to control and supervise their activity.

*There are three main ways to do this:*

- location panel;
- status information panel;
- report summary.

In the case of AGVs, the traction system consists of the speed-controlled motor or motors and the mechanical drive of the traction wheels. There are two cases:

-a motor drives the two drive wheels by means of a differential transmission;

- one motor is mounted on each of the two drive wheels, having the speed controlled by an electronic drive.

Traction motors are controlled by the on-board microcomputer and, in special cases, including breakdowns, by a human operator at the control panel.

*Automatically guided vehicles are designed to move in three ways:*

- one-way and one-way movement, which requires a traction system and a steering system of the vehicle;
- two-way movement, forward and reverse, in which case an additional steering system is required;
- two-way orthogonal movement in both directions, which requires two traction systems and two vehicle steering systems.

*The main types of AGVs used in industry:*

- Wheel locking systems;
- Suspended wheeled vehicles;
- Wheeled vehicles and air cushions, moving on the ground.

When AGV runs, we combine a reactive control method and route tracking to ensure safety. The reactive method is based on the principles of the Polar Bug obstacle avoidance approach (Figure 3), which allows the vehicle to quickly surround dynamic obstacles by laser scanning the scanner.

This method makes many assumptions to simplify the calculation by providing a fast and efficient solution.

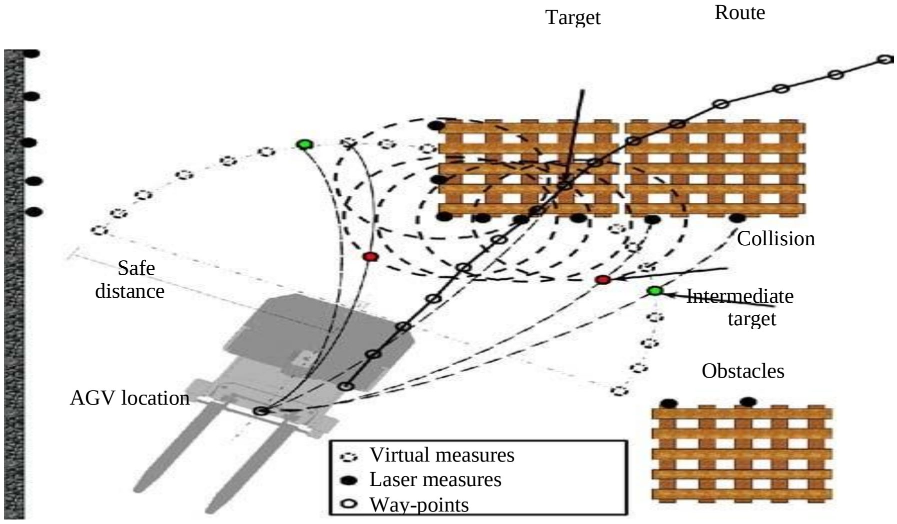



**Fig. 3.** Approaching the Polar Kinematics Bug to avoid obstacles.

*The experiments consist of two stages:*

First, a battery for docking experiments is presented to regulate route tracking, and second, a case study is presented to show the entire system operating as a flexible MHS.

The first experiment aims to demonstrate that the system meets the requirements for performing precise operations with a degree of accuracy, repeatability and industrial reliability.

While the second experiment shows the flexibility and robustness of the system that performs safe operations in industrial environments.

This experiment consists of sending the AGV to a range of industrial products. When the AGV runs from the place where it was waiting for tasks, an unexpected obstacle is found on the way to the reference point for the initialization of the docking maneuver.

## 3. Assembly line case-study

The assembly line produces 3 types of motors. The production capacity is 450,000 enginesyearly with a line cycle time of 0.76 min. The surface of the assembly line is 1427 m², it is organized in an O shape and has a number of 88 stations. The synchronous supply is made of 3 picking areas. The study is performed on picking zone 3.

The assembly line is supplied with parts from the picking area. In the picking-type logistics preparation area, the families of parts are prepared on trolleys, in the order of the manufacturing film: cylinder head cover, distributor, turbocharger and catalytic converter.

The manufacturing film represents the production planning based on firm orders classified according to the dates of their receipt from customers, structured in the production order.

The trolleys are transported to the assembly line by means of an electric tractor, serviced by a logistics operator.

This research aims to optimize the manufacturing flow by supplying the picking areas using new means of transport.

In the current situation, the transport of the trolleys of parts is carried out by means of an electric tractor. This study aims to eliminate this tractor because it generates costs both in the commitment of the operator transporting the carts and in the running time of the tractor.

Improving the supply flow of workstations will be done by replacing the existing means of transport with an AGV, and the solutions proposed to achieve this improvement are shown in Figure 4.

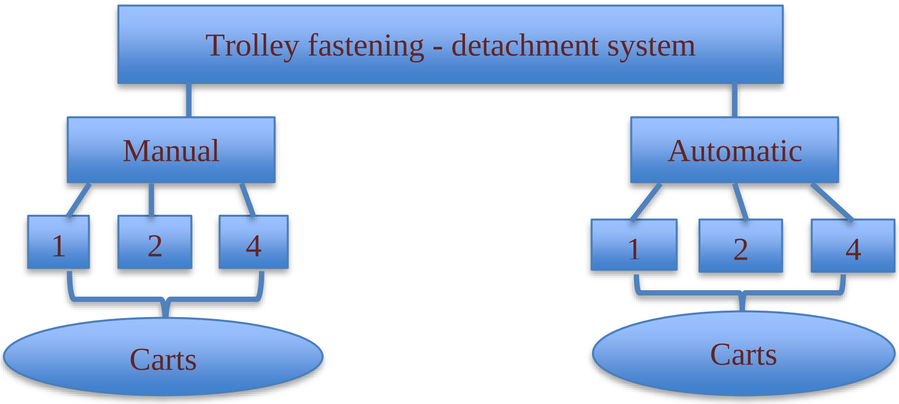



**Fig. 4**. Scheme of proposed solutions.

The operator's commitment and the operating time of the electric tractor will be determined first. A time analysis sheet will be used. In this describe sheet the activity performed by the operator, depending on the distance and frequency of the activity resulting in the time needed to transport a trolley with parts. helped by the implantation plan of the line, the length of the route traveled by the electric tractor for supply will be determined.

The collected data will show that the commitment of the operator transporting the trolleys in the assembly line is 43.26 [%], which results in a cost of 18,170.07 [€] (for the 3 work shifts). The annual cost of labour resulted in making the product between the total commitment of the operator, the number of teams and its cost to be divided by 100. The running time of the tractor being 7.59 min and resulting in a cost of 3,388.41 [€] / year.

## 4. Conclusions

In the following, the results obtained for the proposed optimization solutions will be presented, but also comparisons made between the two means of transport.

In the Figure 5 it can be seen that for the automatic clamping / detaching system the operator cost is zero because it is done automatically with the help of an actuator, which is purchased at the same time as the AGV.

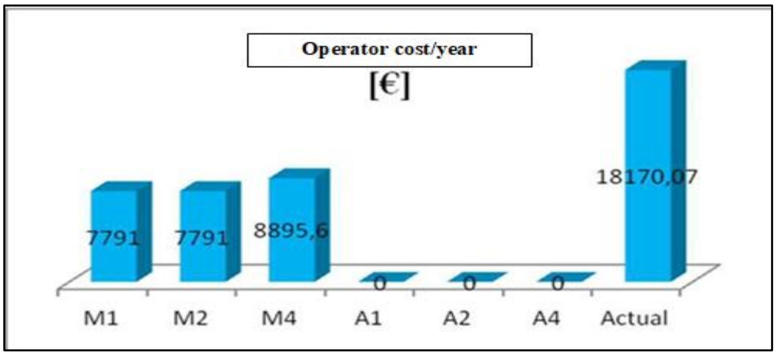



**Fig. 5.** Operator cost per year.

In the Figure 6 it can be seen that for the current situation the tractor must be paid because it is rented, being necessary to pay its rent.

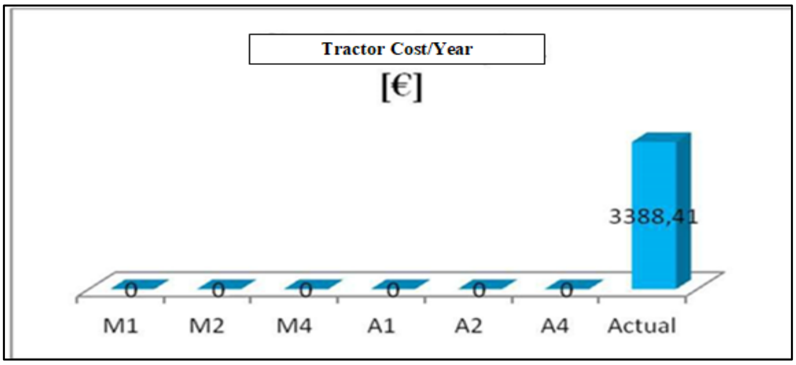



**Fig. 6.** Tractor cost per year.

AGV consumables for each proposed situation is shown in Figure 7. Consumables refer to the fact that every year the AGV battery must be replaced.

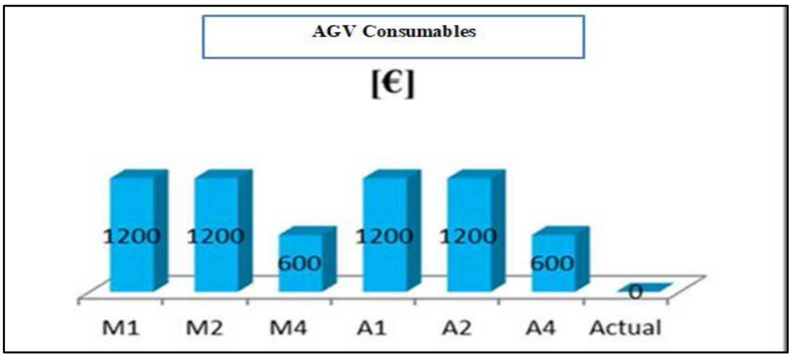



**Fig. 7.** AGV consumables.

It can be seen that for the fastening system - detachment manually with 4 trolleys and automatically with 4 trolleys, a single battery is needed, because only one AGV is required, for each situation proposed to carry out the transport of trolleys with parts in the workstation. And in the case of manual and automatic detachment systems that transport a trolley, respectively 2 trolleys, 2 consumables are needed, and 2 AGVs are needed for these situations.

The total cost of use for the current situation and for the proposed situations is highlighted by Figure 8. In the current situation this cost consists of the operator's cost per year plus the cost of the electric tractor, and for each proposed situation it consists of the operator's cost. per year in which "AGV Consumables" are added.

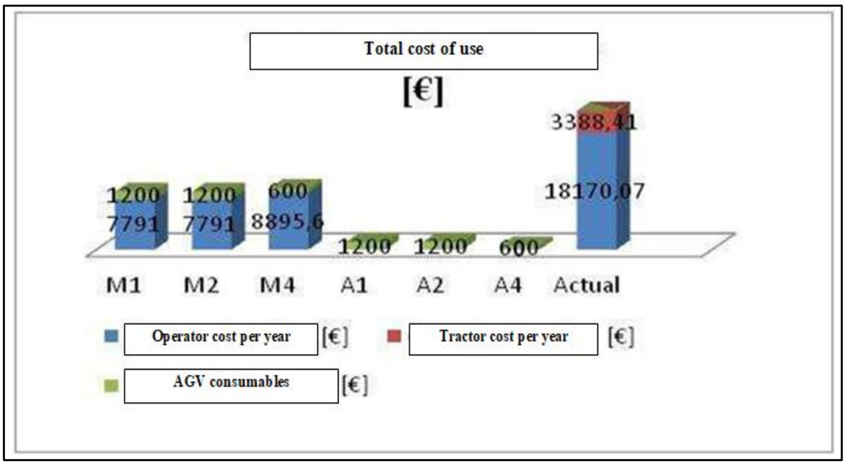



**Fig. 8**. Total cost of use.

This case study presents the improvement of the supply process of workstations within an assembly line.

The optimization methods used in this study were: picking and introducing AGVs as a means of transport. Several comparisons were made between transport with an electric tractor and AGV.

Several situations to improve the supply flow were proposed and then an analysis of investments and costs was made.

From the point of view of the amortization of investments and the costs of use, the optimal variant resulted is the situation in which an AGV is used, whose fastening-detaching system is manual and which transports 4 trolleys (Figure 9).

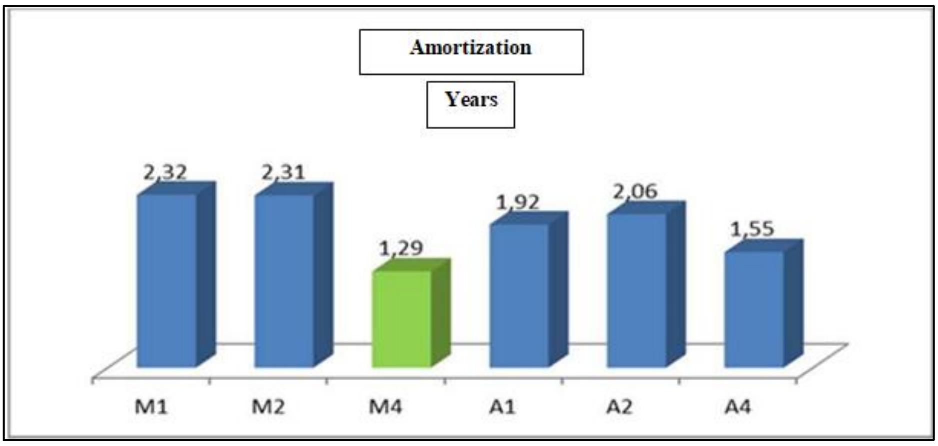



**Fig. 9**. Analysis of proposed situations.

Below is an example of how we should use an AGV in a logistics automation process (Figure 10).

Operating condition: discharge time for red logistics flow = loading time for red logistics flow = discharge time for blue logistics flow = loading time for blue logistics flow. This condition is mandatory, namely that the time intervals are equal so that one AGV does not meet another on the route.



a. AGV in production of suspensions [8]    b. AGV in automobile production

**Fig. 10**. AGVS used in the automotive industry.

Within the Assembly Department, two automations of logistics flows were carried out, implementing and developing the system with AGVs:

• GMP transport circuit (motors) from station MO1 to station MO3

• Sleigh transport circuit on flow D (DUSTER).

The GMP transport circuit (motors) from the MO1 engine preparation area to the MO3 area within the Assembly department was possible to be automated with the help of four AGVs.

Detailed functional analysis AGV section MO1-MO3:

- Nominal operating speed: 60 vehicles / hour
- Working hours: 5 days a week in 3 shifts of 8 hours
- The security features of the AGV are as follows:

a) <u>The bumper</u>. If the bumper comes in contact with an object, the AGV will stop instantly, to restart it we must reset the fault, which is done by pressing the Reset + Master ON button.

b) <u>Mustaches</u>. When the mustache is touched, the AGV will stop instantly, to restart it we must reset the defect by pressing the Reset + Master ON button

c) <u>PBS</u> is the security radar and has the role of stopping the AGV when an obstacle enters its safety area. It has three safety zones, which are signaled by the lighting of a warning light when an obstacle enters that area.

d) <u>The beacon</u> has the role of warning us acoustically and brightly when the AGV is moving, and signals a defect when the AGV is stationary.

Degraded driving: If an AGV fails, it will be pulled off the route, and instead the transport will be performed by the logistics operator with the transport tractor.

Operating Mode AGV GMP - Tronson MO1-MO3:

<u>1. Route for loaded trolley (1500 kg)</u>

• Distance = 200 m, • 2 = trolley loading area, • 1,3,4,6,8,10 = low speed markings, • 5,7,9,10 = speed markings

<u>2. Route for unloaded trolley (200 kg)</u>

• Distance = 200 m, • 2 = trolley unloading area, • 1,3,4,6,8,10 = low speed markings, • 5,7,9,10 = speed markings

This paper presented the design and development of an AGV that incorporates artificial intelligent techniques to increase the autonomy and flexibility of current commercial AGVs.

Development is focused on flexibility and adaptability, given the simplicity and secure needs of industrial applications. The prototype demonstrated the feasibility and adequacy of incorporating modern service robotization techniques to produce a higher level of self-sufficiency and autonomy in a robotics platform for industrial operation.

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