An integrated transport system for a city of 40,000 inhabitants

L. Carlomusto, A.D’Ambrosio, M. D’Ambrosio & A. Villanova

Department of Economy and Territory
Laboratory of Calculus
Cassino University, Italy

Abstract

With the present study we propose a system of integrated transport of a city of around 40000 inhabitants. The city that we have considered was built at a time of less activity than today, with the consequence that the roads are restricted and are not able to cope with the growth in transport and traffic.

A solution is proposed in the form of a driver-less monorail on the existing roads that crosses the roads at about 4 meters in height on a one-way circular run at regular intervals. It is proposed that the new system will integrate with the existing railroad and other ground transport.

From the analysis of the flows of present traffic and projections of those in the future, it has been able to optimise the integrated management systems using standard algorithmic methods and an expert system approach.

It is found that there are technical and economical advantages in managing the new system with the use of the expert system.

Introduction

We with the present study propose a system of integrated transport of a city of about 40000 inhabitants.

The city that we have considered has built when the activities had not developed like today, with the consequence that the roads they have a limited course and they have not stayed developed systems of able transport of offer big ability of traffic.
The development of the industry has required a more and more good mobility of the people. Biggest application of transport has stayed faced with an increase of the circulation of the automobiles. The increase of the traffic of cars has caused a worsening of the conditions of the city traffic, especially in the schedules of opening and closing of the factories. You better you conditions of life of the inhabitants has then even more worsened the situation of the traffic, especially in the summer periods, when the tourists crowd the roads of the city.

The roads that go toward the city is:
- the railway line that Rome colleague with Naples
- the highway that connects Rome and Naples
- the road that goes toward the sea
- the road that goes toward the mountains
  - the road that connects Cassino to Montecassino.

The intense use of the private automobiles has strongly limited the development of a system of urban efficient public transport, especially for the demands of the numerous travellers that arrive to Cassino with the train, or with the buses that arrive from the by of the sea, from the mountains and from the highway. Almost all the tourists that arrive to Cassino go to visit Montecassino, and they must cross the only road (uncomfortable and hold) that connects the city to the
mountain. The traffic of motors to inside combustion gives an elevated pollution due to the incomplete combustion and from products of the combustion during the slope, and provokes an other pollution for the dispersion in the atmosphere, during the descent, of the materials products with the attrition of the brakes. Finally, we must observe that in Cassino, and in Montecassino the space is not enough for the park of all the necessary halves for the in demand traffic. All the preceding considerations on the ecological problems and of efficiency of the systems of urban existing transport there has carried to the hypothesis of build a railway system to monorail on the existing roads of the city, without driver, that crosses the roads to around 4 meters of height.

The run (entirely in the city) of the monorail is circular and the train crosses it in an only verse and to intervals of time regulated in base to the flow of the travellers that book the individuals stops. From the railway station of the line Rome - Naples we have done the hypothesis of the connection with a cableway between Cassino and Montecassino, for allow to the deriving travellers to Cassino with the train of move easily to Montecassino.

We have calculated that the cableway, with a run of around 2 kilometers, needs 4 boxes. While 2 boxes climb, the others 2 descends, limiting the traction strength for the slope of the others with their weight in the sense of the descent 2, with big saving of energy and with limited costs of exercise. We must consider that this system of transport reduces the environmental pollution and the costs that we must face for the transport of million of visitors of Montecassino enormously. With our studies, considering the offer of transport of the people owed the line railway Rome- Naples, we have done the hypothesis of the integration of the new systems with the railroad already existing and the other types of existing earthling transport.

From the analysis of the flows of present traffic and hypothesizing those future, we find the optimization of the integrated management of the systems. The flows of traffic are not constant during the 24 hours, and they also vary as regards the days of the week, as regards the months of the year and in relationship with the particular days of the year. The seasonal variations don't concern however the urban system that, contrarily to the cableway and to the railroad (for the big flows of tourists), it must guarantee the connected shifts with the activities of all days long.

Noting of the fact that the system of transport to monorail has stayed conceived with all the possible automatism (inclusive the automatic guide, without driver), the increase of the question of transport could be resolved with the increase of the frequency of passage of the trains (without that is increase the number of trains). Considered the variability of the question, we have preferred to vary the times of standstill of the trains. When the trains depart, they complete the complete turn in around 15 minutes (inclusive the stops). The time of varied route in base to as we point out in succession. The stops have set to equal distances between they, as the trains are in each instant or all locks or all in motorbike. This circumstance assures the maximum safety of service, because the trains are always to the same distance between them. For the actual flows of traffic, hypothesizing 3 trains in
circulation, with the standstill to the varying stops between 3 and 10 minutes (according to the day, the hour and the bookings to the stops), we have simulated a good service of transport and have verified a degree of optimal filling of the trains.

The regulation of the frequency of passage could be gotten either varying the speed of the trains, or modifying the times of standstill. The regulation of the speed of run could be effected in a circle of speed technically realizable (from 3 m/s to 15 m/s): psychological motivations of the traveller limit the real recourse to all the range technically possible, up to prefer speed of varying point between 10 and 15 m/s. For limit the costs of management during the periods of scarce traffic, the reduction of the frequency of passage could be realized with the increase of the times of standstill to the stops: considered the circular layout, that means that with 3 trains on the run, we could hypothesize are 3 principal stations with longer standstills and the other stations with shorter standstills, it is the subdivision of the standstills between all the considered stations of the same importance. Since stations with flows of traffic exist greater than other (like, for example, the railway central station, the near station to the town hall, the station with the departure for the cableway), we have preferred choose of divide the total standstill in two standstills, that of the 3 principal stations and that of the 9 secondary stations in proportion.

In each of the stations the traveller, with the introduction of the ticket in the signature machine, active the booking of the trip. The data flow together in an informatic system that, departing from the base of the traffic programmed with the other systems of transport, determine the regulation of the frequency of the passages. The system could use an algorithm that pursues the maximum degree of filling of the trains and that guarantees the appointments of the 3 trains with the other systems places in the principal stations.

We with our study have fact the hypothesis then of use an informatic expert system for the intelligent regulation of the frequency of the trains and of the frequency of the cableway. The expert system has given us the possibility of add to the algorithm of management already describet the analysis of the historical flows in the preceding periods and of increase the given basic with the new acquaintances inferred from the facts continually considered. The availability of hardware more and more powerful allows us currently of propose software of systems experienced more and more sophisticated able to behavior hypothesis on the applications of future transport, with excellent results of economy of management.
Basic concept

The purpose of traffic is to move many people (or much goods) in shortest possible time, from point of departure to destination (for instance, moving people between their living quarters and their places of employment). The transport capacity could for instance be measured in how many people can pass through a cross-section of a certain route per hour. The travel time depends on the average speed the vehicles can keep in a certain network of traffic routes. High transport capacity and short travel time will be required if the monorail traffic is to be competitive.

Traffic separation

The monorail traffic turns out to be a formidable traffic machine, which - with a higher level of safety compared to road and rail traffic, at all weather conditions, - provides larger traffic flows and shorter travel times. Both roads and railway tracks can be built with separation from opposing traffic (such as in tunnels underneath cities or with highways on bridges above the cities).

In such cases there will, like in the monorail traffic, be no other kinds of traffic (such as pedestrians and bikers), no opposing traffic, and no crossing traffic on the travel route.

But implementing this traffic separation is - because of the heavy vehicles and space-demanding highways - very expensive and quite cumbersome. And there is still the difficulty of handling sudden obstacles on the route without suffering personal and material damages. This is because human drivers suffer from delays in discovering and reacting to these obstacles, and also because of varying distances between the cabins, varying braking capacity, and poor control of passenger safety.

The doors of the cabins are preferably of the sliding type. In some situations, the opening doors might have to cover each other. In such a case, the "outer" door would be of the swivel type.

Stations with many different kinds of cubicles are space-wasting and inefficient, insofar as some cubicles will be empty while there might be queue of cabins to others, of different transport system.

Control and supervision

The system hypotized is meant to be wholly automatic, but there is always the possibility for the supervising personnel and (under certain conditions) the travelers to take charge of individual vehicles whenever necessary.

The guidance system is the most complex part of all those computerized systems that keep the monorail network running. As the name implies, the Guidance System is supposed to guide the cabins safely and efficiently through the maze of monorail, from start to destination. This component consists of a computers on
each cabin, a central supervising computer and sensors in the monorail to keep the computers informed about the whereabouts of the cabins. There are in principle three different ways to run a system such as this:

- The Synchronous system;
- The Asynchronous system;
- The Point-Synchronous system.

The idea is to safely guide a cabin from start to destination as quickly as possible. For our simple circuit with not much traffic, this would entail only few calculations that goes on all the time the traffic is running. The job is shared between the Central computer, the node computers and the computers in the vehicles, so good communication between these is of crucial importance in order for the system to function, except for the asynchronous system. The Guidance system must also work closely together with the Safety system.

The Addressing System

In a large netsystem, all destinations on the monorail network need to have addresses, otherwise there is no way for computers to direct the cabins to where they are going. One could here benefit a lot by borrowing ideas from the Internet. Anticipating a day in the distant future, when monorail networks from various metropolitan areas make contact with each other and start interconnecting traffic, it would be a good idea to adopt Internet's 32-bit addressing, where the address is hierarchically structured and divided into 4 parts of 8 binary bits each. Each new network would thus be assigned a network number from an international agency. Depending on the plans for the monorail network that is being developed and the size of the metropolitan area in number of inhabitants, it would be decided whether the network would be of class A, B or C.

Copying Internets hierarchical structure, on which its addressing is based, each node in the monorail network would correspond to a router in the Internet, and each berth, station, depot or other place where the cabins would be likely to stop would correspond to a node in the Internet. Thus, the addresses of the nodes on the one hand, and the addresses of the berths, etc. on the other, would belong to different levels of the addressing system, and only the latter category, i.e. berths and other stopping places for the monorail cabins, would correspond to the node address part of the Internet addressing system.

To avoid confusion, one would probably have to adopt a slightly different terminology than the one that applies to the Internet. In a way, the cabins, which all have identification numbers, could then be likened to the data packets sent on the Internet. This addressing system would easily facilitate the subdivision of large monorail networks into smaller administrative areas.

The Booking System

The Booking System would consist of:

- Booking terminals at all stops, at some poles and at other strategic places
- Booking terminals that can be reached by phone or from the Internet
- Contactless cabind readers in the cabins
- Booking terminals in the cabins
- A booking computer
The tasks of the booking computer would be:

- Accept travel requests from the passengers
- Construct, alter and maintain a traffic timetable for the regular traffic
- Collect information as to where and when more regular vehicles are required
- Calculate the need for vehicles at various times and locations in accordance to points
- Provide information about waiting times and number of available vehicles at various points
- Provide this information to the central computer in such a way that this computer can plan and direct traffic

If the central computer is the heart of the system, then the booking computer can be regarded as its brain. It has to continually optimize the timetables and available vehicle capacity at all times and locations, so that the central computer every day has a "prognosis" for the coming 24 hours. This prognosis has to include such occasional events as football games, concerts and the like. The pattern of bookings for private cabins must be prognosticated in the same way. The booking computer also has to provide the network planners with reliable, statistical information about need for enlargement, profitability, extent of travel, need for more vehicles of various categories, etc.

The information system would consist of monitor displays in the cabins, at stops and at other strategic places and the central computer.

The display would continually inform about the valid timetable for various routes, the traffic situation; stoppages, delays, full cabins, whether extra cabins have been provided, the time for next incoming regular cabins and their destinations.

There could be prompted-for information about:

- when an booked vehicle will arrive
- if an order/booking cannot be effectuated
- the status of the traveler's magnetic cabin

It should also be possible for authorized persons to:

- Gain information about where a certain traveler and/or cabin is and where they are going
- Receive various statistical information about the traffic
- Get information about current events, such as congestions and accidents.

This system is controlled by the central computer and is separate from the information that the booking computer provides via the booking terminals. The system would be integrated with the booking system insofar that the cabin reader functionally is a part of the booking system, while answers to orders/bookings of cabins are routed via the central computer to the display.

**Braking**

Emergency braking is normally performed by using the propelling system to feed the cabin's live energy back into the power supply system as electrical energy. This
might have to be supplemented by physical friction-brakes. The propulsion vehicles would be equipped with computer-controlled disk brakes that do not lock the wheels. One could also use disk brakes around the sides of the slot inside the monorail - that would give a very efficient braking. Both these friction-based manner of braking causes a later strain on monorail and supports, that they have to handle. Also, there is a minor drawback to this last system; it wears the inside of the monorail. The inside of the monorail thus has to be coated with a "braking layer" of some sturdy material.

**Loss of Power**

The cabins have batteries to slowly take them to the nearest available station, where the cabins will be stopped. This speed is so slow that the cabins will be able to stop within their radar’s visibility field.

**Loss of Communication**

This situation is potentially dangerous in the point-synchronous system when travelling at high speed. But the cabins will then rely on their radars and keep travelling at a safe speed to the nearest berth, and dock there. They might be permitted to continue to their destinations. It is suggested that the cabins have two-way radio-communication in case the wave-guide system should not work at any time.

When boarding a cabin, it is of course of the highest interest of the passenger-to-be to know where the cabin is headed, and when it leaves and when it will arrive. Bunching people together in big cabins is a cheaper and more efficient way of transportation than having them travel one or two in small vehicles. This is true, even though the driver has been eliminated, but provided that the bigger vehicles do not have to stop along the way. Thus, persons who agree to travel in this manner should be able to travel considerably cheaper than those travelling by taxi-cabins. Thus, there will be a need at certain times and places for cabins that follow a timetable. They will follow the manner of today’s road buses; they have their own platforms where arrival/departure times and destinations are published. They will stop along their routes where passengers aboard indicate that they want off, and the passengers could indicate this at the time of boarding, with the aid of their smart cabins. The cabin will also know where prospective passengers are waiting along the route, because the stops will be equipped with button panels for the purpose, where waiting travelers indicate where they want to go. This is rather similar to today’s regular bus-stops, that are frequented by several bus lines. In many countries, you are supposed to hail an approaching bus, if it happens to be the bus you want to go with. If nobody hails, and nobody in the bus want to get off, the bus will just whiz by.

It is important for an automatically driven vehicle to be able to detect any obstacle in its path of travel. Should this obstacle be a cabin up ahead along the monorail, having some kind of problem and cannot move, that cabin would
report the situation to the central computer in charge, which in turn would broadcast an announcement to other vehicles in the area. But that procedure cannot always be relied upon; the faulty vehicle might not be able to transmit any message about its predicament, for some reason or other. There could also be other kinds of obstacles along the monorail. For that reason the cabinriages beneath the monorail are equipped with obstacle detection devices.

With today's fast computers, the routing table can be allowed to grow to a considerable size without compromising performance. From a computer's point of view, there is plenty of time to decide upon the route to travel. A table containing up to 5,000 nodes should not be a problem. Nevertheless, it is possible to subdivide big networks into smaller units, where cabins mostly will be expected to stay in their own areas. During the simulation phase of big networks in the planning stage, it might be necessary to subdivide them in order to trim certain parameters. It will then be an extra simulation task, when these parameters are trimmed, to integrate the various parts in the final simulation phase.

Conclusions

The endeavor when dimensioning the monorail system is that the transport function should be performed better than today, while at the same time the cost of resources (materials and energy) should be considerably less, and the costs to the environment (in urban areas meaning crowding, noise, exhaust fumes and accidents) should also be considerably less than the situation at hand. It should also be a considerably better alternative in all these respects than all alternative measures that should otherwise have been taken, in order to meet the needs of the immediate and distant futures. These are not small claims. But the automated monorail traffic system has the capability to fulfill these goals.

The advantages for the environment, as a consequence of the reduction of chemical and acoustic pollution am easily imaginable, thank you to the thick reduction of the auto private traffic.

The laws in subject of urban transport favour the use of the public halves, proposing facilitations for the customer also. In any zones of the city it must be present the park for the private cars, where all the peoples can leave their vehicles.