IGT

Intelligent Grouping Transportation

Revolutionary Urban Transportation for 21st Century Cities

Joe Olmi

www.taxibus.org.uk

Contents

1. Introduction

Intelligent Grouping Transportation (IGT) is a revolutionary new mode of mass public transport that can rapidly solve the problems of traffic congestion, parking congestion, vehicle-exhaust air pollution and greenhouse gas emissions with unparalleled efficacy.

IGT is a radical departure from existing concepts of transport, but is a highly practicable and eminently sensible idea, both technologically and in terms of a business model. To start with, IGT is exceptionally cheap to implement by transport budget standards, as it requires no infrastructure changes such as setting up rail networks, excavating underground tunnels, building extra roads, and so forth. More significantly, IGT is the first mode of rapid-response mass public transport that actually conveys passengers from door-to-door , which makes IGT vastly superior to existing modes of public transport and allows IGT to compete with - and perhaps even beat - the flexibility and convenience of the private car, therefore enticing car drivers to travel by IGT.

IGT operates using a fleet of minibus vehicles called taxibuses which travel on the road networks. Typically a taxibus will carry around six to eight passengers aboard, with the taxibus driver guided by street navigation instructions received from a computer system which automatically controls the routing of each taxibus vehicle in the fleet.

Journeying by taxibus is delightfully easy. Prospective passengers request a taxibus ride simply by submitting their current location and desired destination addresses to the IGT computer system, typically using an ordinary cellular telephone. Regularly-used addresses would be pre-programmed on the passenger's phone, so this address submission is very straightforward. As soon as a taxibus journey is requested in this way, the IGT computer system searches its database for a nearby taxibus vehicle whose current itinerary is compatible with the passenger's submitted itinerary. Once a suitable taxibus is found, it is immediately diverted to pick up and convey the new passenger.

New passengers are collected extremely quickly, generally within three minutes of submitting their journey request. Such rapid pick-up is feasible because IGT operates with a large fleet of taxibus vehicles spread across the city, continually travelling the road networks, constantly conveying passengers. A new passenger is allocated to a nearby taxibus vehicle already on the roads carrying commuters, this vehicle's itinerary being modified on-the-fly to incorporate the new passenger.

The three minute pick-up response that IGT achieves using this on-the-fly approach makes taxibus travel vastly superior to existing door-to-door public transport concepts, many of which require prospective passengers to place an order for their journey hours in advance of travel. With IGT, a passenger can spontaneously order a taxibus, even when waiting on the high street, for example, knowing that a taxibus will arrive to collect him usually within one or two minutes. This is an incredibly fast response (the feasibility of which is analysed later).

The IGT system is composed of four main elements:

Taxibus Vehicles that travel the roads
Cellular Telephones & Networks to transmit data
GPS In-Car Satellite Navigation to guide taxibuses
Computer Systems to orchestrate the taxibus fleet

Compared to other modes of public or private transport, IGT has a remarkable overall efficiency. This extraordinary transportation efficiency results from intelligently grouping passengers with compatible itineraries onto the same vehicle. The IGT computer system automatically organises this. The computer system also creates a custom road route for the taxibus which is exactly tailored to the passengers grouped on board such that all are picked up and delivered door-to-door. The taxibus driver is directed along the custom route by the straightforward means of GPS in-car satellite navigation technology. In essence, a taxibus is like a regular bus, but with a completely flexible, computer-generated route weaving through a sequence of passenger pick-up and drop-off addresses, rather than along a rigid bus route with its fixed bus stops. The taxibus concept has become practicable due to the advent of in-car navigation technology and cellular communications technology.

Note that IGT bears little operational resemblance to the 'Super Shuttle' (a small-scale transport system in the US for taking passengers to and from the airport) or to any other type of Demand Responsive Transport. IGT runs an incomparably larger fleet of transit vehicles, and moreover, employs instantaneous, on-the-fly vehicle routing. Only recent advances in technology make it practicable to perform on-the-fly taxibus routing, which makes a sub-three minute passenger pick-up feasible. No other Demand Responsive Transport system has ever aimed for a pick-up response anywhere near as fast as this.

There are many advantages to concurrently transporting several passengers together in the same taxibus. Although the journey obviously takes a little longer than going by car or taxi, taxibus travel is much quicker than a bus ride and is much more flexible and convenient. Grouping passengers with compatible itineraries into the same taxibus allows fare costs to be kept low, comparable to bus fares. Such grouping is also fundamental to decreasing the number of cars on the roads, since people who would have otherwise journeyed in their individual cars can instead travel in a taxibus and enjoy exactly the same door-to-door service that their automobiles provide - and with the added benefit of not having to worry about finding a parking space.

Analysis indicates that introducing a fleet of taxibuses can massively reduce the quantity of road traffic. As much as an 80% decrease in the number of cars on the roads is feasible, yet this remarkable reduction in traffic levels is achieved without decreasing the number of passenger journeys taking place on the road networks (which is important for maintaining the economic vitality of a city). IGT is also a very community-oriented mode of transport, catering for everybody, and bringing together people who share similar itineraries.
The beauty of IGT is that its performance dramatically improves as its scale of operation is increased. The more people using the system, and the more taxibuses there are operating per square mile, the more the taxibus routing efficiency increases. Routing efficiency improves simply because with more travellers, it becomes statistically easier to find passengers with highly compatible itineraries. For large-scale IGT operations, taxibus routing becomes so direct that travelling by taxibus is almost as fast as going by car.

A Taxibus En Route

Note that greater routing efficiency can also be obtained with a small taxibus fleet, if this fleet is confined to a specific area of a city. It is the taxibus vehicle density which is important, not the actual number of vehicles in the fleet. In urban areas, efficiency of scale begins to kick in when there are around 15 taxibuses operating per square mile.

In summary: IGT is an immediate and elegant solution to many critical problems, with the potential to become one of the primary modes of public transport in towns and cities throughout the world. A swarm of IGT taxibuses can be quickly implemented at low cost; they are inexpensive to run and require little or no alteration to the physical and technological infrastructures of the town or city. These characteristics make IGT practicable for both developed and developing nations.

In the long-term, IGT will completely transform the urban landscape, bringing fresher air, much less traffic, and providing a highly efficient public transport service that will greatly improve the quality of metropolitan life.

1.1 The Extraordinary Capabilities of IGT

Here are a few summary facts and figures about IGT.

A fleet of just 20 thousand taxibuses, introduced to a major city such as Paris, New York or London, will provide the city with an astounding 8 million passenger journeys during each 24 hour period. We can compare this to London's 20 thousand licensed taxi cabs which transport around 0.5 million passengers during the same period, or London's 6 thousand buses which carry a total of 4 million passengers each day (in buses that have a capacity of around 80 people). Another point of comparison is the London Underground which provides 2.5 million passenger journeys every day.

Analysis shows that the taxibus vehicles and controlling computer system for this IGT taxibus fleet have a capital cost of around UK £800 million (US $1.4 billion). This is very inexpensive considering that this taxibus fleet will provide more passenger journeys each day than the entire London Underground AND London's buses put together, which is quite amazing. Any city planners considering building an expensive metro system may want to reconsider: they may find they are much better off implementing IGT instead.

An IGT system can also be set up at a fraction of this budget. One of the virtues of IGT is that it can grow organically, and it is therefore possible to implement a very small fleet of taxibuses to start with, serving a specific, localised area within a city. For example: a fleet comprising a few hundred taxibuses, restricted to the central business district of a city, would provide that region with a rapid point-to-point transit service, helping to promote a healthy business ecology in that zone. Equally, a taxibus fleet can be set up to serve a specific residential region, and perhaps helping to forge a community spirit in that area. Later, when budget allows, more taxibuses can be purchased and the fleet extended to cover more areas of the city. Of course, in the case of a small town or village, a tiny taxibus fleet is all that is required to service the whole populace.

As far as the environment is concerned, analysis indicates that in major cities, for every 10 thousand taxibuses introduced, 60 thousand private automobiles can be cleared from the roads, assuming car drivers travel by taxibus instead. In London, for example, there are around 250 thousand vehicles on the roads during the day, and a fleet of 20 thousand taxibuses could reduce this by a net 100 thousand vehicles – a cut of nearly half – which is a phenomenal amount. As transportation generates 90% of a city's air pollution, and contributes to about 30% of an industrial nation's greenhouse gas emissions, IGT's enormous potential to improve the environment becomes abundantly clear.

2. A Ride on a Taxibus

The Following Story Illustrates IGT Travel from the Perspective of a Journeying Passenger

It is 8:22 am in the city suburbs. Alex is taking a last sip of coffee before commencing his journey into work, which is located in the centre of town. He puts on his coat and grabs his cellular telephone. His thumb punches in a few commands on the phone's keypad, and from a list of pre-programmed addresses, Alex selects the destination address labelled 'Office' followed by his embarkation address labelled 'Home'. On the cellular telephone display screen, a validation message summarises the journey that Alex has just requested:-

Taxibus Journey Request

From: Home > 56 Muswell Hill, N10
To: Office > 110 Charing Cross Road, WC2

Passengers: 1

This request for a journey is transmitted to the IGT central computer system. Alex waits a moment whilst the system responds to his journey request. He regularly travels to work by IGT and is completely familiar with this efficient and relaxing way of commuting. A few seconds later, the IGT system details a nearby taxibus vehicle that is available to collect him. These details are displayed on Alex's cellular phone in the following format:-

Taxibus Vehicle Availability

Pick-Up: 2 min
Journey: 34 min
Fare Cost: £1.40
Arrival: 8:58 am

Please Confirm: **YES | NO**

These details tell Alex that, should he opt for it, this taxibus can pick him up in just two minutes, and can deliver him to his office destination at the estimated time of 8:58 pm. Alex hits the YES response to select the taxibus vehicle offered; his cellular phone subsequently displays some confirmatory information:-

Taxibus Selection Confirmed

From:	56 Muswell Hill, N10
To:	110 Charing Cross Road, WC2
Pick Up:	**1 minute 50 seconds**
Taxibus:	Number **4025**

This confirmatory information remains visible and provides a real-time countdown to taxibus pick-up. It is now just under two minutes to go before his taxibus arrives. Alex has just got enough time to check around the house, making sure the doors and windows are closed. His umbrella and briefcase lie by the front door. He grabs the briefcase, but leaves his umbrella behind; he rarely needs his umbrella since he started travelling by taxibus.

Alex glances at his cellular phone: the countdown to pick-up now shows just under one minute. Alex should be outside in the street when the taxibus arrives, so he steps out the house, locks the front door, and walks down to the roadside. A short while later, a taxibus turns into his road. This vehicle has the identification number 4025 marked on it, so Alex knows it has come for him. The vehicle is small and compact: a sleek, narrow minibus with just 9 passenger seats. The taxibus pulls up at Alex's residence, its passenger doors open and Alex climbs aboard. The driver politely greets him good morning, but no money is handed over, nor are any travel passes shown. This is because the taxibus fare is calculated by the IGT computer system and automatically charged to Alex's IGT user account. This makes boarding a taxibus fast and simple.

Inside a Taxibus

There are already a few passengers on board the taxibus. As the vehicle moves off, Alex walks down the small central aisle and finds himself a comfortable seat. The journey to the office has been estimated at 34 minutes; Alex wonders which route the taxibus will take this morning. He knows that there will usually be additional passenger pick-ups along the way, and a few passenger drop-offs too. The IGT computer system provides real-time street navigation instructions on a dashboard display screen to guide the taxibus driver along the customised route. However the computer system ensures that all passenger pick-ups and drop-offs lie along a fairly direct trajectory, so Alex's own journey is not really that much lengthened by them.

Half an hour later, Alex's taxibus is nearing his destination. An interior display screen, visible to all the passengers in the taxibus, shows the upcoming stop, and also indicates which passengers should alight at this stop. In this case it is only Alex, and so his IGT user name (which he has chosen as 'Alex-G') is displayed on this interior display screen:-

NEXT STOP:	Charing Cross Road
Arrival Time:	2 minutes
Passengers Alighting:	Alex-G

The same information is also available on Alex's cellular telephone. Alex gets ready to alight. All taxibus passengers are made aware that they must board and alight reasonably quickly in order to keep taxibus travel fast and streamlined for everybody. Quick boarding and alighting are made possible by displaying on the passenger's cellular telephone a precise countdown to the time that their taxibus will arrive to pick them up, and by providing this advanced warning just before a passenger's destination is due. The fact that all passenger fares are automatically calculated by the IGT system - eliminating the need to buy tickets from the taxibus driver - also greatly helps to expedite the whole transport process. The taxibus arrives at Alex's destination and pulls up at the kerb. The driver announces "Arrival at Charing Cross Road" and opens the vehicle doors. As Alex steps out on to the pavement he observes that, as usual, the IGT system has guided the taxibus right up to the front door of his office. Which is good, because it had just started to rain.

2.1 Advantages of the IGT Taxibus

The taxibus brings spontaneity to public travel: it offers an astoundingly fast and flexible way of making a journey. These are the qualities that make the private car so popular. With the car you just get in and go. The taxibus rivals this 'get in and go' convenience: pull out your cellular phone, punch in your location and destination, and a few minutes later, a taxibus will arrive to collect you. One must reflect for a moment to really appreciate the amazing power of IGT. With your cellular phone or wireless PDA in you pocket, all your urban travel needs are literally just a button-press or two away. For those without a cellular telephone, a taxibus journey can also be ordered using roadside touch-screen kiosks specially-designed for the purpose.

Ordering a Taxibus

The door-to-door service of the taxibus is invaluable for the elderly or mobility-impaired. Many towns have a 'dial-a-ride' or 'paratransit' service for people with mobility impairments, providing minibus door-to-door travel in the local district. Usually passengers must book these rides by telephone a day in advance. IGT can subsume this paratransit service: the IGT taxibus offers more efficient routing and can be requested just minutes before travel. Existing paratransit vehicles, which are specially designed for mobility-impaired passengers, can be incorporated into the taxibus fleet simply by fitting them with the IGT computer technology, which is an inexpensive conversion.

The IGT taxibus does something that the private car very often cannot: delivering passengers right up to the door. For car drivers in most cities, when a parking space or parking garage is eventually found, not only will there probably be a charge for using it, but quite often it will be at some distance from the driver's destination. So the private car often does NOT provide a door-to-door service in practice. This is a problem in bad weather, in areas of high crime rate, and for single women late at night. Leaving a car unattended and out of view can also increase the risk of theft or vandalism.

The door-to-door service of the taxibus has an inherent level of security that neither the car nor conventional public transport can beat. This inherent high security means that the taxibus can safely transport children to school and back on a door-to-door basis, so that parents need not worry about the school run each morning (this will further help clear a great deal of traffic from the roads: in the UK, just before 9 am in urban areas, an astounding one car in five is taking children to school).

The taxibus is particularly convenient for travel to an address in an unfamiliar location. Instead of pre-planing the trip using a street atlas, you simply submit a journey request for travel to this address, and the taxibus will drop you right outside your destination - even if you have no idea where it is! Such is the easy and efficiency of IGT.

The IGT taxibus gives people a great feeling of freedom: wherever you are, a taxibus is instantly available, ready to take you precisely to where you want to go. IGT offers point-to-point transit from anywhere to anywhere. This lends a strong sense of mobility and independence to the traveller; these psychological factors are part of what makes the private car so popular. Nevertheless, though offering freedom and independence, the taxibus is also a friendly, safe, community-oriented mode of transport. So you have the best of both worlds with the taxibus: a socially-inclusive transport system; yet one which provides total freedom and flexibility for the individual.

3. Environmental Issues

Global warming studies predict that emissions of greenhouse gases such as carbon dioxide will create higher average global temperatures, and that these, in turn, will precipitate extreme weather phenomena such as flash flooding or violent hurricanes – and ultimately sea level rises that are likely to submerge many cities and populated areas throughout the world. From the anomalous weather witnessed in the last few years, and from the increased rate of melting of the polar ice caps, it is beginning to appear that global warming is for real. Managing this situation may become one of the greatest challenges to humanity in the 21st century.

Intelligent Grouping Transportation directly addresses this challenge. Transportation is a huge source of greenhouse gases, accounting for around a third of a nation's carbon dioxide emissions. Fortunately, the taxibus offers enormous potential for reducing these emissions. To elucidate this capability, let us take the case of a major city such as London, Los Angeles or Paris. Some simple arithmetic quickly demonstrates the power of IGT: assuming the average taxibus holds 8 passengers during the rush hours, and given that the average occupancy of a car is around 1.4 travellers, this means that each taxibus vehicle can replace around 6 travelling cars (since $8 \div 1.4 = 6$ roughly), thus offering the potential to clear these cars from the roads.

This analysis thus suggests that for every 10 thousand taxibus vehicles introduced, up to 60 thousand cars can be cleared from the roads (assuming car drivers are persuaded to travel by taxibus instead), a net reduction of 50 thousand travelling vehicles. In terms of greenhouse gases and air pollution, 60 thousand carbon dioxide-emitting vehicle engines are reduced to just 10 thousand (or even reduced to zero if the taxibuses are powered by hydrogen fuel). Yet amazingly, this huge cut in traffic and pollution is achieved without decreasing the amount of passenger journeys taking place on the road networks (important for maintaining the economic vitality of a city).

In London, around 250 thousand vehicles are travelling on the roads at any one time. Since introducing a fleet of just 20 thousand taxibus vehicles can clear 100 thousand travelling cars from the roads, this equates to almost a twofold reduction (50% decrease) in traffic. By doubling the size of the taxibus fleet an incredible fivefold reduction (80% decrease) in traffic is possible. This will create a massive cut in greenhouse gas emissions and toxic air pollutants. But would this traffic reduction manifest in reality?

Turning theory into reality means enticing car drivers to leave their cars at home and travel by taxibus. Considerable efforts should be made to make taxibus travel as attractive as possible in order to seduce people away from their cars. This includes providing sleek, well-designed and very comfortable taxibus vehicles that are not only a great convenience, but also a pleasure to ride in. However, should global warming, air pollution and traffic congestion start to become really critical problems – which may well be the case in the near future – then more coercive means of getting car drivers to switch to the taxibus may be necessary. Such means may include running persuasive advertising campaigns, increasing road and fuel tax for car drivers, providing corporate tax incentives for companies that champion taxibus usage, and so forth. It is believed that once the public realise the ease and simplicity of travelling by taxibus, using the car will seem a little clumsy. Eventually, few people will want to return to their old driving habits, especially when they see how traffic-free the roads have become.

Altogether, it is believed that the taxibus will have a tremendous impact in cutting global carbon dioxide emissions if the IGT system is implemented in many cities around the globe.

World-wide implementation of IGT is much more feasible than one might first think. Although IGT comprises a sophisticated information-technology based transport system, the beauty of IGT is that all its complexity is contained within the computer software rather than in the transportation hardware. Compared to the complex and costly physical infrastructures of railway and metro networks, the hardware of IGT is very basic: comprising just taxibus vehicles and roads. This makes IGT extraordinarily robust. It also makes it very easy to implement: most countries have the required cellular networks in place, and all countries are covered by satellite electronic positioning. With these infrastructures already in operation, IGT can be set up virtually anywhere, both in advanced and developing nations. Indeed, the developing world's heavily polluted and traffic congested cities stand to benefit the most from IGT.

3.1 The Taxibus Combats Parking Congestion

We have seen how the efficiency of IGT arises from the concurrent transportation of several passengers at once, which dramatically reduces road traffic levels, air pollution and greenhouse gas emissions. By contrast, the private car occupies pretty much the same road space as a taxibus – and emits roughly the same amount of toxic exhaust products – yet typically carries just the driver. This is a negligent disregard for human health and the environment as well as an inefficient use of the road networks.

Yet as if that were not bad enough, the private car harbours a further disturbing inefficiency. Statistics show that the average automobile is utilised for only 10% of the day (the typical car is driven for less than 1.5 hours each day). The rest of the time, which is 90%, the car lies idle, parked, and usually taking up road space. Considering this usage inefficiency, it is not surprising that the kerbs on most main roads and residential streets are crammed with parked cars. If the usage efficiency of private cars were 100% then clearly no parked or stationary vehicles would be seen anywhere, apart from when dropping off or picking up travellers or delivering goods. This is self-evident, but it is worth repeating this point because it is normally overlooked: the reason our kerbs are so overburdened with parked cars is not just due to the level of vehicle ownership, but also related to vehicle usage efficiency, which as stated, is a meagre 10%. A simple equation describes parking congestion:

Number of Parked Vehicles =
Number of Vehicles Owned X (100 – Usage Efficiency) / 100

We have become so accustomed to seeing parked vehicles clogging up towns and cities that we assume this is an unavoidable consequence of enjoying the convenience of motor transport. But it is not: the above parking equation implies that if vehicle usage efficiency is increased, the number of parked vehicles will decline proportionately, and that increasing vehicle usage efficiency to 100% will result in having very few automobiles parked in the streets. A taxibus vehicle's usage efficiency generally tends towards a perfect 100%, because the IGT computer system tries to ensure that all of the taxibus's time is dedicated to active transportation. Once the taxibus delivers a passenger, it does not remain idle, but continues conveying other people. The private car, on the other hand, tends to be quite useless once the driver has parked and departed the vehicle.

In the modern urban context, the fact that the private car must be parked when it arrives at its destination can be considered a sort of design flaw in this transport mode. Consider the amount of time that is lost looking for parking places, the parking fees that must be paid, the inevitable parking fines, vehicle clamping and tow-away costs, the cost of building massive multi-level car parks, the running of controlled street parking, the cost of buying parking area land for offices, shopping centres and sports centres, and so forth. Still further expense results from salary costs for the staff that must regulate these parking zones.

Even when drivers are on the move, parking still affects their journey. In many towns and cities, smaller roads are effectively reduced to a single lane due to the density of cars parked on both sides of the road. This ridiculous situation is particularly problematic in European cities, where road widths are much narrower compared to the United States. By effectively reducing a two-way road to a single lane, parked vehicles frequently force car drivers to pull over (into whatever gaps are available between the parked vehicles) to let oncoming traffic squeeze past. Parked vehicles are like cholesterol on the road arteries of our cities.

In a future where the taxibus has taken over from the car as the primary form of urban travel, parking congestion will be of historical interest only, and kerbside parking space will once again become abundant. Perhaps the streets will never quite revert to the era when they were largely clear of vehicle clutter, but with a comprehensive taxibus service in place, the current epidemic of idle kerbside automobiles can be abated.

4. London Case Study

Let us examine how a taxibus fleet compares to existing forms of transport. We shall take Greater London as our case study, but our analysis can be applied to most major cities. During each 24 hour period in central and outer London, around 25 million passenger journeys take place. These divide modally as follows.

9 million	Private Car (as Drivers)
6 million	Private Car (as Passengers in above)
4 million	Bus
2 million	London Underground (Metro)
2 million	Walking
1 million	Train (Surface Rail)

Source: Department for Transport. Figures have been rounded.

Other modes of travel in Greater London (motorcycle, taxi cab, mini cab, bicycle) are fairly negligible in comparison. The relative importance of these transport modes is somewhat reversed as far as peak-hour travel to and from central London is concerned: morning peak hour (7 am to 10 am) passenger journeys into central London divide modally as follows.

0.5 million	Train (Surface Rail)
0.4 million	London Underground (Metro)
0.1 million	Private Car (Either as Driver or Passenger)
0.05 million	Bus

Source: Department for Transport. Figures have been rounded.

How would a London-based taxibus fleet compare? Consider a fleet of just 10 thousand taxibus vehicles. Assume an average vehicle occupancy of 6 passengers, and a typical passenger journey time of about 20 minutes (since the average vehicle speed in London is 20 mph and the average journey length is 7 miles). A quick calculation then shows that such a taxibus fleet would complete 180 thousand passenger journeys every hour. In a 24 hour period, the fleet could in principle handle 4.3 million door-to-door passenger journeys, which is an absolutely formidable number.

We can compare this taxibus fleet to London's 6 thousand buses, which carry 4 million passengers each day, mainly in double-decker vehicles having a capacity of around 80 passengers. Another point of reference is London's 20 thousand licensed taxi cabs which, throughout every 24 hour period, manage to transport 0.5 million passengers.

How will the fleet of 10 thousand taxibuses cope, theoretically at least, with the 7 am to 10 am rush hour commute from the suburbs to central London? Assuming, during these rush times, an average taxibus occupancy of 8 passengers and an average commuter journey length of say 40 minutes, then a simple calculation shows that the taxibus fleet will manage to transport over 0.36 million commuters during these three hours. This is a very impressive figure, almost equalling the performance of the entire London Underground system during the same time period.

What about the operating profit and the running costs of the taxibus fleet? The major running costs will arise from driver wages: this fleet of 10 thousand taxibuses will require around 30 thousand drivers working in 8 hour shifts to keep these vehicles on the road 24 hours a day, 7 days a week (based on only a reduced taxibus service running at night). Assume each driver costs a total of £25,000 (US $44,000) per year for salary and other costs, then the wage bill will amount to £750 million (US $1.3 billion) annually. Fuel costs for this fleet can be calculated at £300 million (US $520 million) a year, assuming the fleet uses diesel fuel charged at UK prices, with each taxibus giving around 20 miles per gallon. Note that fuel costs will be much lower in the US, where fuel is less expensive.

Further costs will be incurred from vehicle servicing and maintenance, and the expenditure of running the IGT computer system. Telecommunications costs should be minimal, since only low volumes of data are transmitted. Driver training costs will also be low: a standard driver's licence will suffice since most of the taxibus vehicles will be not much larger than a regular minibus or 'people carrier' type of motorcar. Taxibus drivers will not need to have knowledge of the street layouts, since electronic street navigation information is provided by the IGT system at all times.

What about the sales revenue generated? Setting the taxibus passenger fare at a modest 15 pence (US 26 cents) per mile, and assuming an average vehicle occupancy of 6 passengers, with an average vehicle speed of 20 miles per hour, then the daily (24 hour) revenue collected by the fleet will be £4.3 million (US $7.5 million). This adds up to nearly £1.6 billion (US $2.8 billion) a year, which should easily cover the running costs of the taxibus fleet.

Regarding the capital cost of introducing such a taxibus fleet: most of the investment will arise from buying taxibus vehicles; the computer technology that runs IGT is relatively cheap. Assume each taxibus vehicle costs £30,000 (US $52,000), which is the typical current price of a multi-purpose vehicle or minibus: it will then require a capital investment of £300 million (US $520 million) to purchase a fleet of 10 thousand taxibus vehicles. Not only is this a modest figure by transport budget standards, but this amount might even be accommodated within the annual profits generated by such a fleet.

It is interesting to examine the figures for a larger taxibus fleet. Suppose the fleet is increased to 30 thousand taxibuses. This requires a capital investment of £900 million (US $1.6 billion) to buy the vehicles, a team of 90 thousand drivers to keep them moving, £2.25 billion (US $3.9 billion) a year in driver salaries, and £900 million (US $1.6 billion) a year on fuel; such fleet will generate an annual revenue of £4.7 billion (US $8.2 billion), and provide almost 13 million door-to-door passenger journeys each day - a figure that is close to the daily total of passenger journeys made by private car in London. Thus a fleet of 30 thousand taxibuses can do more or less the same job as London's 2.3 million privately-owned cars. We could therefore dispense with many of these cars. This possibility is not just a utopian vision: it is a glimpse at what cities of the future will be like. The taxibus has the potential to transform urban life and the city landscape.

Does it make economic sense for a Londoner to sell his car and travel primarily by taxibus? Let us consider this question. Ownership of the average car can be calculated at around £10 (US $17) a day inclusive of fuel, road tax, insurance, servicing, maintenance, and vehicle depreciation, but exclusive of parking costs. The average vehicle covers a distance of less than 30 miles each day with an average occupancy of 1.4 travellers: this equates to a cost of 24 pence (US 42 cents) per person per mile, excluding any parking fees. Comparing this to the 15 pence (US 26 cents) per mile taxibus cost, this analysis suggests that it does make good economic sense to sell the car and adopt the taxibus, although the precise economics will greatly depend on individual circumstances. Families with children may not be so keen to sell the car, since the car becomes more economically viable when there are more travellers. A special discount on taxibus fares might be offered to family groups in order to make the taxibus more financially appealing to families.

The ultimate objective of the taxibus is not to eliminate the private car, but to seduce people away from the car by providing a taxibus transportation network that the public will come to view as a much more convenient and convivial way to travel. The taxibus aims to compete with – and beat – the private car in terms of transport excellence; winning people over just by the superb service IGT offers.

Note: the above transportation and financial performance analysis of the taxibus is based on an assumed average vehicle occupancy of just 6 passengers; if higher average vehicle occupancies are achieved, say 10 passengers per vehicle for example, then all the above performance figures will be proportionally improved.

4.1 The Three Minute Response Time

The success of the taxibus as an everyday means of transport will crucially depend on the time a prospective passenger has to wait for a taxibus to arrive to pick him up. To compete with the 'jump in and go' immediacy of the private car, it is considered that a taxibus must appear within three minutes of a passenger making a journey request. Is such a rapid response feasible? Some simple analysis can answer this question. Again we shall take Greater London as our case study (but the conclusions of our analysis are applicable to other towns and cities).

The total area of Greater London (the city centre plus the suburbs) is around 610 square miles. Assuming we have a fleet of 10 thousand taxibuses more or less evenly spread across this area, this gives an average vehicle density of 16 taxibuses per square mile. The UK's Department for Transport statistics indicate that the average road speed in London is around 20 mph. In order for a taxibus to arrive within three minutes of the passenger submitting his journey request, the responding taxibus must be situated no further than one mile away (since at the average road speed of 20 mph, it takes exactly three minutes to travel one mile). How many taxibuses are there within a one mile radius of the typical waiting passenger? The answer is simply the area of a one mile radius circle (which is 3.142 square miles) multiplied by the taxibus vehicle density per square mile. This gives 16 x 3.142 = 50 taxibuses. This is a fair number of vehicles, and since these 50 taxibuses will have a wide variety of itineraries, there is a high chance that one or more will be travelling in a direction compatible to the passenger's desired destination. (This probability also depends on the closeness of the passenger's destination: the closer the destination, the higher the chance of finding a taxibus with a compatible itinerary. Note that the average journey length in London is just 7 miles, so most destinations are in fact quite nearby.)

This simplified analysis is no substitute for a more in-depth mathematical modelling of taxibus response times, but it does strongly suggest that a three-minute response is eminently feasible.

The other important consideration in studying the feasibility of a three-minute passenger pick-up response relates to the computer processing power necessary to perform optimal routing within this timescale. The mathematics of optimal routing often involves calculations that consume a lot of computer power (often demanding processing power in a manner exponentially related to the problem size). For this reason, most Demand Responsive Transport (DRT) systems find it hard to calculate optimal routes even given 24 hours notice, and the very the fastest-responding DRT systems require an hour's notice, in order that their computers have time to determine the optimal routes for passenger pick-up and delivery. So how can IGT perform the almost instantaneous route optimisation that is necessary for on-the-fly routing and a passenger pick-up that is within three minutes? On first analysis, this seems like a mission impossible.

Paradoxically, however, the tight constraint of a three-minute response actually makes taxibus route optimisation much easier. This is simply because this rapid response greatly reduces the number of routing possibilities in the computation. When a prospective passenger submits his journey request to the IGT system, only a relatively small number of taxibuses out of the whole fleet will be able to reach him within three minutes, so obviously the system just needs to examine the itineraries of these close-proximity taxibuses in order to determine the optimum vehicle to carry the passenger. Mathematicians term this process of cutting out irrelevant possibilities from the calculation as 'pruning'. There are many further pruning possibilities even within this subset of close-proximity taxibuses.

So finding an optimal route for an IGT taxibus can be done pretty rapidly: not much computer power is really required. It is very important to appreciate this double advantage of the three-minute response. Not only does this attractive feature put IGT way ahead of all rival DRT systems, but in addition, IGT's three minute response greatly reduces the computer time required to perform the optimal routing calculation. In this sense, the three-minute response is self-enabling.

Finally, note that without the cellular telephone and its ability to send, receive and display text data, the three minute response - and IGT in general - would be less feasible. Sure, you can use other communications means for ordering a taxibus, but the cellular phone is obviously extremely convenient, ubiquitous, fast and simple to use. The advent of cellular telephony is a vital enabling technology for IGT.