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The design, management and operation of flexible transport systems: Comparison of experience between UK, Japan and India

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ABSTRACT

Flexible transport systems (FTS) can offer an alternative to fixed route fixed schedule bus services in situations of low and dispersed demand. Although it is widely recognised that these on-demand services provide a better level of service to passengers at a lower operating cost than the infrequent fixed route services which they often replace, they still require significant financial support to cover their costs. As local authority budgets to support public transport continue to be reduced the sustainability of these services is being brought into sharper focus. In this paper we compare and contrast the development of FTS in UK, Japan and India. In particular we examine the extent to which new technologies are being used to contribute to a reduction in operating costs in the UK and Japan and whether these developments point to a future model for sustainable flexible service provision in developing countries, using India as an example.

1. Introduction

The objective of this paper is to compare various design, management and operation aspects of Flexible Transport Systems (FTS) in three different countries: UK, Japan and India. These aspects cover various primary issues on system architecture and performance, technology usage, integration with other modes of transport, legislation and policy issues, and market viability and subsidies. Recent developments in FTS design, management and operation in the UK and Japan are used to identify likely future challenges, key issues and directions for next generation FTS in developing country environments such as India.

FTS are broadly defined as a transport service where at least one of the characteristics (route, vehicle, schedule, passenger and payment system) is not fixed. In the public transport context, this contrasts with the service which has a fixed route, fixed timetable and fare, and vehicles with drivers scheduled on a regular basis. In general, with respect to flexibility, cost and comfort, FTS is considered as being intermediate between fixed route, fixed schedule public transport and personal vehicle use. There are different versions of FTS across the world; from existing literature and state-of-the-art practice we can broadly categorise FTS into *formal* and *informal*.

Formal flexible transport services have been documented extensively (e.g. Enoch, Potter, Parkhurst, & Smith, 2004; Mageean & Nelson, 2003; Mulley, Nelson, Teal, Wright, & Daniels, 2012; Velaga, Nelson, Wright, & Farrington, 2012). They are usually operated with small buses, minibuses and maxi-taxis and can be either for general public use, or can be for closed user groups such as special services for people with disabilities and the elderly. In this paper, the focus is on the provision of services for the general public which includes people with disabilities and the elderly where appropriate vehicles and services are provided. Formal FTS operates largely in developed countries according to defined rules and regulations. In providing transport services for members of the public there are four principle forms of licence and regulation which exist:

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- Legislation related to type of service operated. To ensure that all services are run by properly licensed operators and to provide an element of stability to the network.
- Legislation related to the type of operator. To safeguard the travelling public and serves to ensure there is fair competition between operators, e.g. by preventing operators from lowering safety standards by cutting costs.
- Legislation related to vehicle specification. Main aspects of vehicle legislation include:
  - only components and systems that have been tested and approved as meeting specified performance standards can be used in public service vehicles,
  - vehicles must comply with emissions standards,
  - vehicles must comply with certain accessibility measures,
  - vehicles must be fitted with speed limiters,
  - for certain uses seatbelts must be fitted and seats must be forward facing
- Legislation related to drivers. To protect employees, passengers and customers from the effects of working excessively long hours, there are several pieces of legislation that restrict drivers' working hours.

Informal flexible transport services are paratransit-type services run illicitly (without licenses or recognition), for a group of passengers with a flexible route, schedule and unfixed fares. Informal FTS are very common and play an important role in supporting day-to-day public transport in the developing world (Cervero, 2000). Generally, these informal services are carried out using minibuses, vans, taxis, station wagons, three-wheelers etc. Informal FTS were initially started over half a century ago (in 1960s) in Mexico City with the "*Peseros*" programme, which allows taxi drivers to pick-up multiple passengers during peak hours (Cervero & Golub, 2007). There are many examples of informal FTS from less developed countries which are well used and are commercially viable to the operators: e.g. the Kombi shared taxis of Cape Town, South Africa; the Taxi Collectives of Havana, Cuba; the Dolmus of Istanbul, Turkey; the Taxi Train of Mauritius, Motorcycle-taxis in Bangkok, Thailand and Rio de Janeiro, Brazil, and the Jeepneys of Manila, Philippines (see Enoch et al., 2004, for a more comprehensive review of these services). Recently, there have been moves to 'formalise' several of these services with greater regulation in order to improve safety, comfort and control especially for those services acting as feeders to the mass transit network (e.g. Tangphaisankun, Nakamura, & Okamura, 2009; Wilkinson, 2008). However, lessons from the developed world have highlighted the risks to commercial viability of these services from increased regulation. Experiments with shared-ride taxis and jitney services in Seattle, San Diego, Indianapolis, and several other U.S. cities, in the late 1970s and 1980s demonstrated there is a market demand for frequent, on-call, and sometimes door-to-door services that are cheaper than exclusive-ride taxis. However, Cervero (1996) reports that regulations governing urban transportation have been built up, layer by layer, over time to the point where today they represent significant obstacles to market penetration and service innovations. Entry and service restrictions are placed on taxis in most U.S. cities, while jitneys, shared-ride taxis, and most other for-profit ridesharing services have generally been regulated out of existence (Cervero, 1996). The comparison between characteristics of formal and informal FTS is provided in Table 1.

In the developing world, as urban populations increase, they can no longer be served in an efficient manner by low-capacity informal transport and the notion of mass transport needs to become mainstream. The challenge for developing countries is to adapt the unco-ordinated informal FTS to a more formal and organised operational structure, capable of interchanging with formal high-capacity public transport to provide first and last mile transport. However, it is critical that this is achieved in a manner that retains the advantages of low public investment and flexibility of the informal services.

Table 1
Formal vs informal FTS.

Formal FTS	Informal FTS
Operate legally and authorised	Illicitly ply their trade; no official endorsement
Good planning, scheduling and dispatching of vehicles	Poor planning and service; no logical approach
Controlled operation and efficient energy consumption	Uncontrolled operation
Authorised taxes and fees	Unauthorised fees and revenues are completely dependent on ridership and demand
Easy to rationalise from a public policy perspective	Difficult to rationalize from a public policy perspective
Mainly established in developed countries	Well established in many third-world cities; and very supportive for poor people
Safe and restricted capacity	Sometimes overcrowded vehicles, and unsafe driving habits (generally in developing crowded cities) (Cervero & Golub, 2007)
Small number of operators under a firm	Many independent operators without control or regulation.
Possible to integrate with other transport modes	No integration with other modes
Requires significant public subsidy	Commercially viable operations

Through examination of the development of FTS in three countries (UK, Japan and India) this paper investigates whether new technology can provide the means to introduce the benefits and positive characteristics of formal FTS to informal schemes without creating barriers to market entry, stifling innovation and incurring additional financial costs associated with restrictive legislation. In the UK case flexible transport services are formal, well established, small in size but more numerous, focussed largely in rural areas and on elderly and socially excluded users. There has been a gradual take up of transport telematics by some larger services although this is sporadic. Japanese FTS has been more recently formalised and occurs in a mixture of urban and rural environments. The potential of advanced transport telematics in urban schemes has been demonstrated. In India flexible transport services are of an informal sharing type, and open for all people. Although operating commercially the system remains inefficient due to a lack of co-ordination and exhibits widely varying levels of comfort and safety.

2. Development of FTS in the UK

FTS in the form of dial-a-ride services for the elderly and disabled have existed in the UK since the 1970's. However, public or open access FTS did not emerge until the 1990's. This was largely as a consequence of bus deregulation in 1986 which, by the mid 1990's, led to a concentration of fixed route bus services on the most lucrative and commercially viable routes where demand was high. Conventional fixed route bus services in lower demand rural areas and at evenings and weekends were cut or withdrawn by commercial bus operators leaving regional and local government to contract commercial operators to provide subsidised services. Funding demands for these subsidised bus services has grown dramatically since the mid 1990's (see Fig 1) leading many local authorities to consider FTS as lower cost alternatives to heavily subsidised fixed route services. FTS can offer a more efficient service in areas or at times of day where demand is low or widely dispersed,

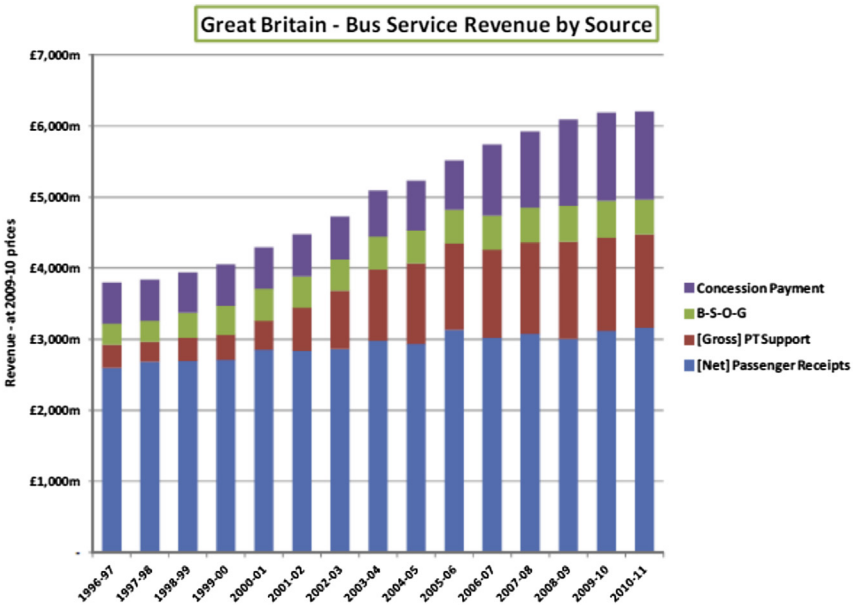

Fig. 1. Bus service support, Great Britain 1996–2011.
Source: Overview of Bus Industry Performance, GB, since Deregulation. Alan Howes Associates, Dec 2011.

operating only when actually requested by passengers. This can be achieved at a lower cost to rigid fixed route services as it avoids unnecessary mileage associated with empty running and can result in shorter daily operating times, thereby reducing driver costs.

In the UK, there are many formal FTS in operation but they are typically small in size, with often only one vehicle per area served, and largely exist in rural areas. Laws, Enoch, Ison, and Potter (2009) provide a review of FTS in England and Wales while Scottish Executive (2006) reviews the FTS schemes operating in Scotland at the time. Fig. 2 illustrates the growth in FTS schemes delivered by 68 government authorities and 11 community transport (CT) organisations in the UK since 1997. Davison, Enoch, Ryley, Quddus, and Wang (2012) conducted a more recent survey of demand responsive transport in Great Britain which identified 369 schemes (approximately half the authorities in Great Britain responded to the surveys). This survey revealed the most frequent reasons for providing FTS related to providing accessibility, including when conventional bus services have been withdrawn, for example. This is followed by providing for the social need of a population or a segment of the population and/or access to a specified service, categorised as a social objective. Economic objectives of reducing subsidy requirements through replacing conventional bus services with FTS was the next most common explanation for introducing FTS. In terms of users of FTS in the UK it is significant that the majority of passengers are elderly. Davison et al. (2012) report that, in 60% of FTS schemes surveyed, more than 75% of users were over 60 years old. These are mostly schemes in rural areas. However, the situation is similar in urban areas where FTS exist. E.g. the (former) Nexus *LinkUp* public FTS operating in the Newcastle metropolitan area carried 70% of passengers who are over 60 years old (Nelson & Phonphitakchai, 2012).

While FTS have proved a relatively popular alternative to more heavily subsidised and underused fixed route services in rural areas or at times of low demand, there is still a significant support cost to supplying these services. Fares rarely account for more than 25% of operating costs and the shortfall is required to be met by public funds. Reductions in local government funding over the last few years has meant that all local authorities are having to find ways of reducing the requirement for public transport support. It is forecasted that current cuts in local government funding will result in a 20% reduction in local bus services (MVA Consultancy, 2011). FTS is not immune to these cuts.

The most significant costs associated with bus services are related to labour costs. For conventional bus services this related to between 60 and 70% of operating costs. However, FTS has the additional requirement that call centre staff must also be employed to manage the on demand booking requests. Mageean and Nelson (2003) found that if a dedicated call centre is provided, this can

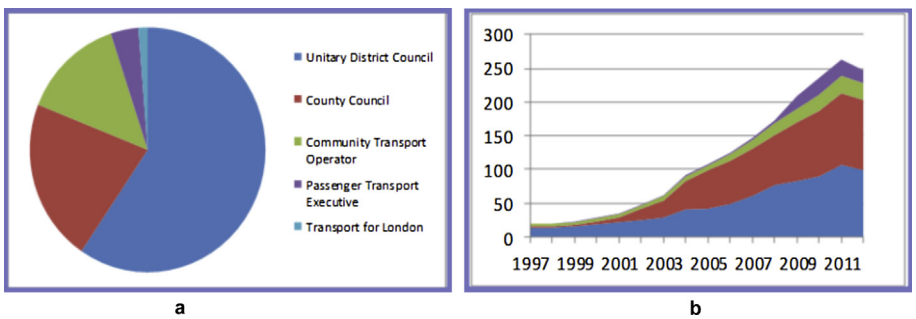

Fig. 2. a: Survey respondents by organisation type. b: Number of FTS by organisation type.
Source: DRT for DRT project survey (March–Oct 2011).

add additional operating costs for FTS of between 20 and 40%. This can negate the savings associated with lower vehicle, running and driver costs of FTS compared to conventional bus services. To minimise this additional cost, some FTS providers have outsourced the booking operations to third party shared call centres. For example Wiltshire County Council subcontract their FTS booking operations to a call centre located in Exeter in the county of Devon and hosted by the provider of the Traveline public transport information service in the South West of England (which also takes FTS bookings for the neighbouring counties of Cornwall and Dorset). This has reduced the additional cost of the call centre to below 10% of operating costs (see Enoch et al, 2004).

Although there is a further additional cost associated with the use of technology in FTS, it is widely accepted that it can aid with accommodating higher levels of patronage as well as reducing the requirement for manual intervention in the booking and scheduling process and staff costs associated with this. Advances and uptake of technology to support FTS has occurred gradually in the UK but this has been largely limited to larger schemes purchasing and housing stand-alone booking scheduling and dispatching (BSD) software on their own servers within a call centre or Travel Dispatch Centre (depicted by the third column in Fig. 3). There are examples of these dispatch centres offering BSD services for other FTS – sometimes for neighbouring authorities or for smaller community transport operators within their own area (depicted by the fourth column in Fig. 3). This can help share the cost of providing the dispatch centre staff and technology costs across a larger number of transport schemes; Lincolnshire and Durham county councils offer examples of where this has been achieved.

A more recent approach for delivery of the BSD software involves access to the BSD software and database through remote web connection on an ASP (Application Service Provider) basis to a centrally controlled server housing the application (depicted by the fifth column in Fig. 3). There is no need for transport providers to purchase and manage central servers and databases and so this approach reduces setup costs, has faster implementation times, lower ongoing support costs, removes many maintenance problems and facilitates access to multiple users located in separate locations and organisations. It is ideal for smaller organisations and offers the potential to foster more and better integration between providers in different sectors. There is also the possibility to greatly reduce dispatch centre staff costs through automation of the booking process using interactive voice response systems (IVRS), web or text booking. However, the adoption of this new technology has been limited in the UK due to the aversion of many smaller operators towards such technologies and the large numbers of FTS passengers who are elderly and not comfortable with automated booking without the assurance provided with human contact via phone. Laws et al. (2009) report that despite two thirds of local authority FTS schemes surveyed utilising booking and scheduling software only 20% offer any alternative method of booking to phoning a staffed call centre. The CTA Scotland nationwide 'State of Sector' survey conducted between August and October 2011 included questions provided by the University of Aberdeen on the use of technology by Community Transport groups. The clear message from the results of this nationwide survey is that the majority of CT providers in Scotland have little ability or appetite to use new technologies for booking and scheduling FTS. The reasons being that technologies do not work in many of the rural areas in which they operate – internet speeds are slow and unreliable and mobile phone coverage has many large 'holes'. Furthermore, the typical passenger is elderly and not a user of internet or mobile technology. CT providers often don't have internet in their offices and would be ill equipped to use it if they did. Crucially, the majority of respondents voiced concerns about the introduction of technologies for booking services highlighting the point that the social contact offered by talking to a person when making their booking is a valuable part of the CT service provided to elderly and often socially excluded members of their communities.

While there has been limited success in the UK regarding the reduction of staff-related dispatch centre costs through greater use of automated booking technology, there has been more concerted efforts to reduce the costs associated with vehicles and drivers through greater use of community transport and voluntary drivers where possible (DfT 2011) and increasing use of smaller vehicles and taxis (see Wright, 2013). The Local Transport Act 2008 provided changes in legislation and funding mechanisms which support this. By way of example, Glasgow City Council have avoided paying

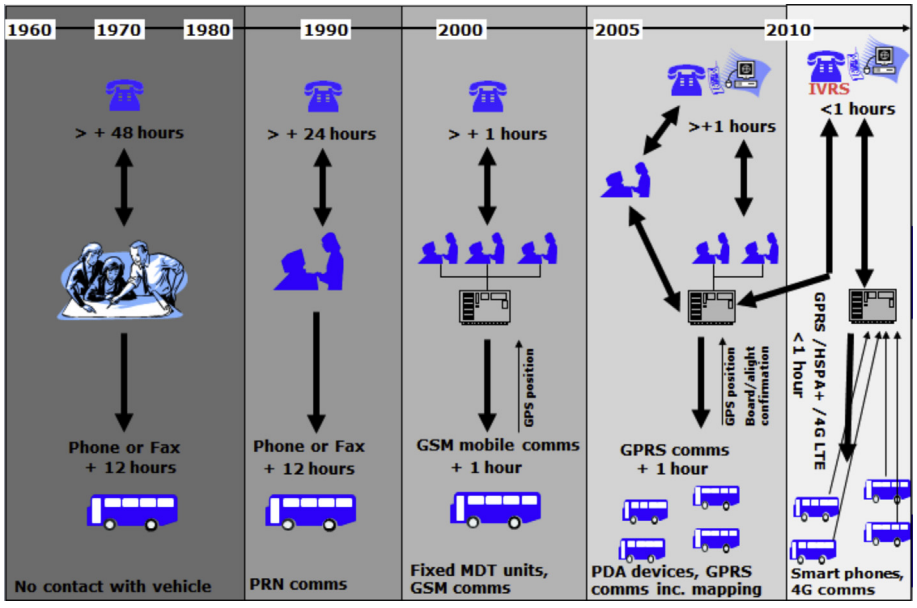

Fig. 3. Evolution of technologies to support FTS in the UK.

overtime to council workers using Glasgow City Council vehicles for evening and weekend flexible transport services by contracting community transport organisations for providing these services while retaining the booking and dispatching within the Strathclyde Passenger Transport call centre. This resulted in savings of about 40% of the operating costs during the first year (ICMA Amobilife project Good Practice factsheet http://www.eltis.org/index.php?id=13&study_id=3273).

3. Development of FTS in Japan

Japan deregulated its bus industry in 2002. Prior to this time incumbent operators were allowed to enjoy a situation of local monopoly but were forced to maintain non-commercial services through cross-subsidy of these non-commercial routes. Following deregulation operators have had freedom of exit and have abandoned non-commercial services. Similar to the UK this has led to a need for state supported services where routes are not considered commercially viable. These are provided as 'community buses' operating on fixed routes. (see Takahashi (2007) and Sakai and Takahashi (2013) for a more detailed description of the Japanese local bus market before and after the deregulation). As in the UK, the funding requirement for these subsidised community buses has grown rapidly since deregulation in an unsustainable manner and the financial burden to the local authorities is huge – Takebayashi and Nitta (2009) report that six out of ten community bus routes receive three quarters of the operation costs in subsidy payments from the local authority. Sustainable public transport services that reflect the demand of the local areas are urgently sought.

Prior to 2006, in Japan, there were only two main modes for road passenger transport: fixed route buses and private taxi. Other forms of vehicle sharing were very exceptional. However, in 2006, the government took an initiative to introduce formal flexible transport services. Fig. 4 illustrates that between fixed route bus and flexible route high cost private taxi, there are two forms of FTS: (1) Demand Responsive Transport operating under Road Transportation Act Section 4 and; (2) Special Transport Services (STS) operating under Road Transportation Act Section 79.

- Special Transport Services are generally provided in urban areas and are designed managed and operated for elderly and disabled people by non-profit organizations. However some cases are designed managed and operated by local authorities. These cases are provided for not only elderly and disabled people but also the general public in rural areas. There are around 3000 special transport services operating in Japan (MLIT: Ministry of Land, Infrastructure, Transport and Tourism of Japan).
- Demand Responsive Transport services play a minor role in the transport market but numbers have increased rapidly in recent years. In many areas FTS are being introduced to replace fixed route community buses and some local authorities facilitate and support FTS as an integral part of the local public transport network. MLIT reported that at least about 160 demand responsive transport services were operated in 2009. Part of the reason for the rapid increase of FTS is that a number of local authorities are looking to alleviate the financial burden of community buses. It is reported by University of Tokyo researchers that in some cases these demand responsive transport services require about half the subsidy of the fixed route community buses that they are replacing (http://www.nakl.t.u-tokyo.ac.jp/odb/en/02_intro.html). On the other hand in Chubu district transportation bureau, MLIT reported that the average of total operation expenses of FTS is smaller than that of community bus but the subsidy cost per passenger was still high.

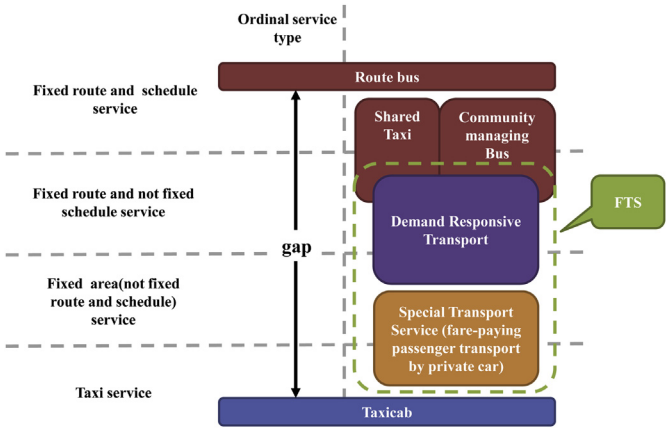

Fig. 4. Japanese FTS.

Many operators of FTS in Japan have introduced ICT facilities. There are two main types of ICT dispatch systems for FTS in Japan. One is the NTT-East system and another is the University of Tokyo system. NTT-East system is called "Demand Transport System" and by 2009 was introduced to about 50 FTS schemes (http://www.ntt-east.co.jp/business/solution/transport/?link_id=lnavbd). The University of Tokyo system is called "On-demand Bus" and was introduced to 44 FTS schemes in 2013 (http://www.nakl.t.u-tokyo.ac.jp/odt/example.html). However, more than half of the demand responsive transport schemes have not introduced ICT vehicle dispatch systems but dispatch vehicles manually (e.g. using taxi radio). According to a survey on the actual situation by MLIT (http://www.mlit.go.jp/common/000050027.pdf), the reasons for not introducing ICT systems are mainly cost and demand problems. Additionally, many FTS systems take the form of semi-fixed route and/or scheduled. Chubu district transportation bureau of MLIT reported that about 30% of FTS in Chubu district of Japan follow a semi-fixed route and schedule form. Semi-fixed FTS are easier to dispatch manually and in many cases ICT vehicle dispatch systems are not required.

Although ICT dispatch systems for FTS are not ubiquitous in Japan they are relatively widespread and it is likely that their use will increase further in future. This is especially the case as more and more urban community buses are being replaced by FTS. Urban FTS is more suited to the application of ICT dispatch for two main reasons. Firstly, the level of demand is higher and so necessitates the need for automated technology to aid in the scheduling and dispatching process. Secondly, the passenger age profile is much younger and more technology savvy in urban areas. For example in the Kashiwa city FTS 60% of passengers were under 45 years old with only 20% over 65 (Tsubouchi, Yamato, & Hiekata, 2009). Crucially, this has led to less aversion to the adoption of new technologies and to greater automation of the booking process in Japan.

In the early 2000s, the Japanese Government started to encourage development of ITS, including ICT dispatch systems, and some demonstration experiments were conducted. A common weakness found in these urban FTS trials was the essential requirement that users needed to place a call to an operator. This incurred call centre staffing costs for providing the service and could be inconvenient to the user when calls were not answered immediately due to high demand. In response to this the University of Tokyo "On-Demand Bus" research team has been developing and testing a system where operators are unnecessary. In order for there to be no need for operators all users must use the Web,

mobile phones, email, or push buttons to place a reservation. It means that resistance to use FTS of younger passengers is reduced. To facilitate 'operator zero' for people who find it difficult to use Web, mobile phones or email a simple reservation terminal has been developed. This narrows down the functions involved in booking a trip (after an initial registration process is completed) so that subsequent reservations can be made as easily as using an automatic ticket machine at a station or an ATM terminal at a bank. This has been introduced as one of the programmes on regional broadcasts in digital television, so that reservations could be made using a TV remote control.

The other major advance made by the "On-Demand Bus" research team is related to the algorithm developed to deal with optimal scheduling of high demands to multiple vehicles. Previous algorithms which solve this type of dial-a-ride problem with multiple vehicles have resulted in exponential increases in calculation time with increasing demand, which makes their use in large scale problems impractical when an immediate response to a reservation request is required by passengers. A new 'insertion and time adjustment algorithm' (Tsubouchi, Yamato, & Hiekata, 2010) was developed which produces a linear, rather than exponential, increase in calculation time as more reservations are added and when the number of vehicles increases. This has been trialled in several high demand environments in Kashiwa City, Chiba Prefecture, Sakai City, Osaka Prefecture, Moriyama City and Shiga Prefecture (Tsubouchi et al., 2010) which demonstrated that the developed scheduling algorithm is practical for use in multi-vehicle urban systems with high passenger demands. A further feature of the "On-Demand Bus" system is that it has the ability to utilise cloud computing technology to integrate across service providers. Tsubouchi states that the technology cost of the 'on-demand bus' system using a shared server cloud computing architecture is between 1/10th and 1/20th that of a traditional technology set-up. Removing the main costs associated with technology application in FTS can reduce overall operating costs by approximately 20–40%.

While the application of new forms of ICT FTS has been demonstrated to operate successfully in high demand urban environments in Japan, the high costs associated with driver salaries places a limitation on the expansion of FTS on a commercial basis in developed nations. However, these advances in technology and cost reductions associated with new technology applications does lend itself to application in developing country environments, where vehicles are smaller and more numerous in number and driver costs form a much smaller proportion of operating costs. We now look at the informal FTS operating in India and assess the potential that is offered by the new technologies being implemented in UK and Japan to deliver more coordinated and accountable yet sustainable FTS.

4. Development of FTS in India

In the Indian context, the various modes/vehicle types considered for FTS are: mini-bus, shared taxi, van pool, car pool, maxi cab, matador van, phutphut, tempos, auto-rickshaw, trekker, cycle rickshaw, man-pulled rickshaw, tonga, etc (Lathura, 2006). According to the study by Mani and Pant (2012) about 75% of the global auto-rickshaws population (three-wheelers, which carries about 3–5 passengers) is found in India. Another study concluded that the informal FTS daily mode share is about 3–8% (depending on size of the city) of daily trips in Indian cities (MoUD, 2008). Private taxi and FTS are closely related; where passengers share taxis it is considered as FTS. This type of informal vehicle sharing is very common in rural areas and also some parts of cities like Chennai, Mumbai, Lucknow, Indore, Rajkot etc. Examples of such informal flexible transport systems in India are illustrated in Table 2. These services typically operate out of assigned shared taxi/rickshaw stands. The owners or operators of these vehicles have their own unions at their local or city level. The fare structure (i.e., charges per km), timings, route fixing, frequency of informal transport largely remains unregulated; and when regulated, it was through the local unions which normally followed some informal mechanisms (TERI, 2012).

The Indian transport system is adopting the concept of providing flexible and integrated transport facilities to its users. Presently, transport service design is made more flexible and integrated by adopting: (1) Introduction of shared taxi service; (2) Carpooling or vanpooling; (3) integrated ticketing system; (4) harmony between various modes and operators, based on time schedule; (5) Real-time multi-modal passenger information. However, the existing service design of informal FTS in various Indian cities is different. It mostly varies according to the user demand, service availability, geographical area, local government and traffic control authorities. The present informal FTS (paratransit operating on a shared basis) is concentrating on maximising the passenger capacity, hence maximising the profit. In most cases the Indian FTS is informal in its planning, operations and management. Although the FTS are improving accessibility and mobility and have become more affordable to the poor, the lack of regulation leads to problems and inefficiencies in operation. These are related to inappropriate planning, uncontrolled operation, unauthorised fees, overcrowding, longer waiting and travel times, unsafe driving habits and no integration with other modes.

Clearly, enhancing the existing informal FTS has the potential to improve the overall transport system in India, particularly in relation to providing an attractive service for the first/last mile connections to/from major transit lines (Chandra, Bari, Devarasetty, & Vadali, 2013; Chidambara, 2012). However, the existing informal FTS is yet to integrate with different modes of transport with respect to service timetables, fares and ticketing system and information provision. To understand what would make such a service attractive to users it is necessary to identify passenger requirements and their views on enhancements needed. Such requirement identification has not previously been done in the Indian context. Therefore, as part of this research 160 face-to-face short interviews were conducted in urban and suburban areas of Mumbai, India. Out of 160 respondents 48 respondents use

Table 2
Informal flexible and shared transport systems in India.

City (and state)	Type	Remarks
Alwar, Rajasthan	3 wheeler share autos (Vikram)	Operates in about 7 routes carrying around 15 people each trip
Jaipur, Rajasthan	Minbuses and Vikram Share autos	Operates in 36 routes carrying 4,500,000 passengers yearly
Mumbai Metropolitan Region	3 wheeler autos	Ordinary autos converted as share autos
Rajkot, Gujarat	Autorikshaw taxis called as 'Chakdas'	Around 6000 chakdas covering 4,000,000 passenger trips
Indore, Madhya Pradesh	Minbuses and vans, Tata Ace magic and Maruti Vans, LPG Autos	Around 500 minibuses and 550 mini vans, Vikram Share autos were banned
Lucknow, Uttar Pradesh	3 wheeler shared autos (Vikram)	Around 4000 autos

personal vehicle for their daily commuting and 82 respondents use public transport for their daily travel and the remaining 30 participants depend on taxi or auto. During the survey, the interviewer explained about flexible and integrated transport system, then further discussed the existing shared informal FTS in India, followed by description of more formalised version of FTS (i.e., well planned, operated and maintained version of FTS), which is currently existing in some of the developed countries. After this description, participants were asked whether they would be willing to use such formal flexible and integrated transport system (if it exists); 81% of participants responded positively. In response to the question on the most influencing factors for daily travel, over 53% of the respondents noted that travel time and safety were the most influencing factors followed by comfort and cost; waiting time was the 5th most influencing factor. Although the relatively low influence of waiting time as a factor influencing travel behaviour suggests door-to-door travel may not be a big attraction, the influence of travel time is a strong advocate for FTS where drivers can alter routes to avoid the worst pockets of congestion. 49% of the respondents mentioned that for an integrated multi-model transport system there should be integrated payment system for the complete journey. 48 participants out of 160 participants (i.e., 30%) stated that use of current FTS (shared paratransit system) would reduce their comfort level. More than 50% of the participants who currently use public transport for their daily commuting stated that developing door-to-door flexible transport would have positive influence on travel time (i.e., reduced travel time). Participants also mentioned that any flexible transport system should be "well planned", "reliable" "use advanced technology as western countries do", "provide quality travel experience in terms of economy and comfort", "user friendly system", amongst others.

Currently, in India coordination between individual intermediate public transport owners (i.e., taxis, auto-rickshaws) is through their corresponding local and regional unions. Furthermore, the existing systems are very simple, informal and use low technology systems. From the survey results it appears that there is a desire for more formalisation of FTS in relation to safety, comfort and cost as well as through better planning of services and coordination with other modes. This could be introduced through legislation to impose greater regulation on the industry, however, issues related to road transport legislation and policies are handled at different levels by several departments and agencies in the region. Regulation related to FTS and shared transport in general is ambiguous and there is a lack of clear understanding on who is responsible for generating and then enforcing legislation related to FTS. As per the Motor Vehicle Act 1988, based on the type of permit granted, a non-commercial permit vehicle (i.e., owner of a motor vehicle) shall not use or permit to use the vehicle as a transport vehicle in any public place. Normally all paratransit vehicles are registered as commercial permit vehicle. There is no separate vehicle registration policy for sharing of private vehicles or cars. This suggests there are many inherent complications associated with introducing legislation to formalise FTS. In addition, experience from abroad suggests that additional regulation will add significant additional cost to providers, which in turn will be passed onto passengers. This raises the interesting question of whether technology could be used to improve the quality and efficiency of FTS in a manner that provides an acceptable surrogate for more regulation.

Much of urban India has experienced rapid development of telematics infrastructure and extensive use of mobile and telecommunication systems in recent years. As per global mobile statistics 2013, India holds the second largest mobile handset market in the world; 73.1% of the Indian population own at least one mobile phone. There are 27 million smart phone users in urban India (Singh, 2012). In the last decade, in India, the application of smart phones is widely used in various areas such as transport, agriculture, education, employment, healthcare etc (Donor, 2012; Fafchamps & Bart, 2011; White, Duggirala, Kummamuru, & Srivastava, 2012). Associated with this there has been some recent adoption of technology in the provision of FTS in India. This has been motivated by the desire to improve the passenger experience and to better co-ordinate services and match supply with demand.

A new phone app named Metershare[2] developed by students in Mumbai, India, encourages strangers going the same direction to meet up in order to share a taxi or an auto-rickshaw and to share the fare. In order to facilitate this, the app relies on a host of new technologies, including Facebook (for user identification), Google maps (to identify routes), and Google "auto-complete" (to ensure that users are identifying their location using standard terms). After inputting "to" and "from" locations on the map, the app presents users with all existing available rides on the same route. To enhance the safety of sharing with a stranger user authentication can be provided through links to Facebook or other social network sites. The metered fare is calculated by the app so the users know what to expect in advance which makes it more difficult for the drivers to overcharge. Finally, the fare is shared with the other passengers in an equitable way, which provides much lower cost. Other similar apps, such as Suruk,[3] developed for rickshaw users enable user rating of drivers to allow passengers to be informed of those with previously good history of safe driving or which provide above average comfort. This allows them to be selective in the driver/vehicle they choose. Negative user ratings will have a direct impact on the driver's ability to attract fares and so will motivate drivers to improve comfort and safety through more careful driving and perhaps more frequent cleaning and maintenance of the vehicle. These user-led examples (there are other similar apps e.g. Smart-Mumbaikar, Zinghopper, Khali Seat) demonstrate how technology is being used to address passenger concerns related to cost, safety and comfort without the need for additional regulation and without imposing any extra costs on drivers.

These innovative services facilitate FTS through the development of ridesharing networks, rather than the building of a specialized FTS fleet of shared vehicles. To establish a more co-ordinated fleet of FTS, which integrates with the rest of the public transport network requires a more sophisticated approach where vehicles in a fleet are better connected through a co-ordination centre for scheduling and dispatching. Two examples of these are discussed here:

4.1. Case 1: dial-a-rickshaw service (Ecocabs) in Fazilka, Punjab, India

The service is similar to the traditional dial-a-bus or dial-a-cab service; but in this case cycle-rickshaw (Fig. 5a) services are made available via a phone call (through a network of call centres) for door-to-door services. The main aim of the Ecocabs service is "improving the unorganized cycle rickshaw transport system in the town and providing affordable means of mobility to the city residents" (TERI, 2013). The project was initially launched in June 2008 with a group of 500 rickshaw-pullers in Fazilka. The service was operating through 5 call centres. Further in 2011, the service was extended to 9 call centres in 9 different zones of Fazilka area to

[2] https://play.google.com/store/apps/details?id=com.positive3.metershare.android.

[3] https://play.google.com/store/apps/details?id=com.ideophone.suruk&feature=also_installed#?t=W251bGwsMSwxLDEwNCwiY29tLmlkZW9waG9uZS5zdXJ1ayJd.

a b

Fig. 5. a. Ecocabs (source: http://ecocabs.org/gallery/). b. G-Auto (source: http://www.g-auto.org/).

attend to the customer requests. Further, Rickshaw pullers are provided with mobile phones, which act as the communication mode between the call centre and Rickshaw pullers. The Ecocabs project received the "National Award of Excellence" in 2011 from the Ministry of Urban Development, Government of India. The success of the Ecocabs scheme in Fazilka has led to the introduction of the same concept in 22 other cities of the state. Moreover, other cities such as Delhi, Chandigarh, and Jaipur and other states like Haryana are also considering similar schemes for promoting sustainable mobility (TERI, 2013).

4.2. *Case 2: G-Auto services in Rajkot city, Gujarat (India)*

Before, June 2012, there were more than 12,000 auto-rickshaws (see Fig. 5b) in Rajkot city providing informal shared services in a highly unorganized manner resulting in inappropriate and uncontrolled planning, operation and management of the fleet. Such a system is not only inconvenient and unsafe to passengers but also not of optimal benefit to the operators due to unco-ordinated service design and operational inefficiencies. Recognizing the large benefits offered by the auto rickshaws in terms of door-to-door service, flexibility in operations and capability to enhance mobility, the Rajkot Municipal Corporation introduced a 'dial-a-rixa' service and promoted a more formal manner of service provision with respect to trip request, reservation and co-ordination between control centre, drivers and vehicle dispatch (TERI, 2013). It is worth noting that through this project there was an improvement in the quality of services for passengers as well as efficient operation of fleet for service providers.

Both the above examples highlight the willingness of both individual owners/drivers who compete with each other and passengers to utilise a central booking office to receive booking requests and allocate trips to drivers. However, to generate the maximum possible benefits from across a large fleet of vehicles there is a need to utilise sophisticated scheduling and dispatching software.

In India almost all of the shared transport systems are low technology based approaches (e.g. Dial-a-rickshaw service – Ecocabs in Fazilka, which is a phone-based service). While there is an additional cost associated with adoption of new technologies these are not significant to the driver and are likely to be more than balanced by the benefits and efficiencies brought about from improved coordination. In terms of managing the system, new technologies will reduce the requirement for staff time answering phones which again will balance the costs of implementation. As a result it is unlikely that introduction of new technologies will result in any significant additional costs for users.

The experience from Japan, in particular relating to the development of the University of Tokyo 'On-Demand Bus' system suggests that this software could be introduced in the India context at very low cost and be suitable for optimal scheduling high demands across very large fleets of FTS vehicles. The opportunity to automate the booking functions will also be attractive to the rapidly expanding smart-phone users and can incorporate features related to fare calculation, social network user authentication and verification and user led driver rating.

5. Discussion and conclusions

This paper has examined the design, management and operation of FTS in three countries, UK, Japan and India. The focus has been on how technologies are being applied to FTS to aid and facilitate aspects of design, management and operation and importantly the potential offered through transfer of the technologies demonstrated in UK and Japan to the Indian context.

The paper explains how FTS booking, scheduling and dispatching technology has been introduced in UK since late 1990's. The experience from the UK demonstrates that technology costs are significant when introduced on a service by service basis. The emergence of cloud computing and remote server set-up since 2005 has the potential to greatly reduce the technology costs per service. Smart mobile devices with built in GPS and mapping functionality has also greatly reduced in-vehicle hardware costs. However, due to the nature of the environment (low demand, single vehicle schemes provided by technology averse operators for mainly elderly passengers) in which FTS is delivered in the UK there has been limited adoption of these new technologies. As a result the staff cost of manual dispatching has remained a cost barrier to FTS expansion in the UK. Japan, on the other hand, is experiencing a small but growing emergence of FTS services in higher demand urban areas with a generally younger passenger base. This has led to the development and demonstration in three key technology areas: 1) enhanced scheduling and routing algorithms to cope with multiple vehicles and high passenger demand without exponential increase in calculation time; 2) remote server/cloud computing approach offering low cost access to the dispatching technology for multiple operators; 3) fully automated booking services which eliminate, or at least vastly reduce, the requirement for staffed call centres. Despite these advances, FTS is still limited in scope and scale in Japan due to high labour costs (mainly for drivers) resulting in the need for on-going subsidy of FTS. It is suggested that India may provide the ideal environment for these evolved technologies since India has a very pressing need to provide more formalisation of its FTS through greater co-ordination and better scheduling of very large vehicle fleets with high passenger demands. The very low incomes associated with auto-rickshaw drivers mean that Indian FTS can operate in a commercial manner requiring no subsidy. The downside of this is that these drivers have very limited ability

to pay for new technologies. As cloud computing/remote server hosting of the technology incurs little or no up-front funds to finance the co-ordination it can provide, the financial barriers to adopting the technology by the multitude of independent low income auto-rickshaw drivers are very low. The high levels of mobile handset owners and the rapidly growing numbers of smart phone users in urban India suggests the automated booking features may also be very attractive to many FTS users.

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