
Investment and Prioritization of Public Transport in Saudi Arabia By ENG. Abdulaziz Alsalem Ministry of Transport – Saudi Arabia

Rebranding ONTC to Mwasalat A welcome move, but what’s next for Oman By Dr. Rakesh Belwal Sohar University - Oman

Household Travel Surveys Who uses public transport in MENA? By Aline Delatte Senior Researcher – UITP MENA CTE

An Innovative Framework for an Intelligent Transportation Data Center in Egypt (EGY-ITrans) By Dr. Ahmed Ibrahem Mosa Advisor to Minister of Transport - Egypt

Challenges of Urban Form for Public Transport in fast growing Cities of the MENA Region By Tammam Nakkash Founding Partner - Team International

Informal Transport in MENA, We Don’t Know Enough By Amr Ramadan Senior Researcher – UITP MENA CTE

Big Data and Public Transport A powerful approach to improve transportation services and performance: The Case of Casablanca Tramway By Patrick Vautier and Stephen Webb RATP - MENA
Dear readers,

We are proud to announce the launch of the first ever MENA CTE Journal. We would like to thank all of the contributors and we look forward to future contributions in the next edition. The authors include experts and high level executives from the leading public transport companies in the region, key decision makers from MENA public transport authorities and distinguished academia. This year’s articles span a diverse range of topics that are both relevant and interesting for any public transport stakeholder. They address some interesting common trends and developments in the region.

One of the most noticeable challenges addressed by our authors in several of the submitted articles is the need for better data collection in the region and recording and monitoring of transport activity using traditional survey methods, as well as new innovations and technologies. Several of the articles also call for the need to advance Transport Demand Management (TDM) in MENA cities recognizing the importance of good governance in advancing public transport.

Of course as a Center of Transport Excellence in the region, we welcome these developments and hope to play our part in this trend through our research and training programs. We also hope, that though the support of our member organizations’ contributions, we can develop this journal into a leading professional public transport journal in the region.

UITP MENA CTE Team
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MENA Center for Transport Excellence (CTE) was launched in 2011 as a joint effort between Dubai’s Roads & Transport Authority (RTA) and the International Association of Public Transport (UITP) to unify regional efforts to build sustainable transport systems in MENA countries.
# TABLE OF CONTENTS

## UITP MENA TRENDS

### 8
Multimodal Integrated Smart Sustainable Transport System: The Way Forward For Mena Cities (Part I-travel demand management)

*By Dr. Khaled A Abbas*
*Expert in public transport - RTA - Dubai - UAE*

### 18
Investment in and Prioritization of Public Transport in Saudi Arabia

*By ENG. Abdulaziz Alsalem*
*Ministry of Transport – Saudi Arabia*

### 20
Rebranding ONTC to Mwasalat

*A welcome move, but what’s next for Oman*

*By Dr. Rakesh Belwal*
*Sohar University - Oman*

### 23
Household Travel Surveys

*Who uses public transport in MENA?*

*By Aline Delatte*
*Senior Researcher – UITP MENA CTE*

### 27
An Innovative Framework for an Intelligent Transportation Data Center in Egypt (EGY-ITrans)

*By Dr. Ahmed Ibrahem Mosa*
*Advisor to Minister of Transport - Egypt*

### 32
Challenges of Urban Form for Public Transport in fast growing Cities of the MENA Region

*By Tammam Nakkash*
*Founding Partner- Team International - Lebanon*

### 35
Informal Transport in MENA, We Don’t Know Enough

*By Amr Ramadan*
*Senior Researcher - UITP MENA CTE*

### 42
Big Data and Public Transport

*A powerful approach to improve transportation services and performance: The Case of Casablanca Tramway*

*By Patrick Vautier and Stephen Webb*
*RATP - MENA*
In many cities in the world and particularly MENA cities, travel demand is growing at very fast rates. On the other hand, the provision of transport networks and modes is constrained by limited funding and at sometimes inefficiencies in planning, design, construction, procurement, operation, maintenance and management. This growing demand accompanied by inadequacies of transport supply lead to several accessibility (traffic related) and mobility (service related) problems. Consequently metropolitan cities are suffering from acute traffic problems, see figure 1 including congestion causing delays and hindering mobility, reduction of safety records, substantial environmental degradation in terms of air and noise pollution and increase in energy consumption.

The intensity of the above stated traffic problems can be minimized if accessibility & mobility are targeted to the movement of people rather than being oriented to the movement of vehicles.

1. ADDRESSING TRAFFIC PROBLEMS

Addressing traffic problems should be based on packaging a number of complementary strategies, policies and measures. Such integrated packages cannot be a random combination of measures or management practices. Which measures are selected will depend on the type and intensity of the traffic problems at hand as well as on the environment, in which these will be implemented. However, until now most traffic relieve programs can be described as being piecemeal approaches, i.e. looking at separate solutions for single problems at single sites. These, when implemented alone, provide marginal relieve to traffic problems. This paper identifies a comprehensive inventory and categorization of demand and supply-based strategies, policies and measures that are aimed at relieving traffic problems in metropolitan cities.

Figure 2 identifies 8 main areas including Roads, Traffic Management and Control, TDM, LUM as well as user, vehicle, fuel and traffic rules related measures. Additionally figure 3 develops the concept of 3Es that was further developed to 5Es while the paper proposes the 10 Es integrated measures to relieve traffic problems (Engineering – Education – Enforcement – Ergonomics – Emergency – Economics – Evaluation – Encouragement – Environment – Empowerment/Enabling).
2. MULTIMODAL INTEGRATED SMART SUSTAINABLE TRANSPORT SYSTEM

This research develops and adopts the vision MISS TS which is an abbreviation for Multimodal Integrated Smart Sustainable Transport System, see figure 4. Such system can be characterised by:

- Providing for multimodality and integration between all public and private transport modes
- Providing passengers with seamless journeys
- Providing smart and fully integrated ITS solutions to operators and passengers.
- Most importantly accounting for all dimensions of sustainability including the economic/financial dimension, the social dimension, the environment and energy dimension and at the core the safety and security dimension.

The paper briefly discusses the strategies available for attaining MISS TS including TDM, LUM and ITS. The paper demonstrates the importance of the integration of such strategies and others in order to enhance accessibility and mobility, and mitigate traffic problems. The core of the paper lies in developing a comprehensive classification of policies, measures and actions falling under the TDM strategy.

3. ACCESSIBILITY & MOBILITY STRATEGIES

Several strategies have evolved throughout the years for relieving traffic problems and providing sustainable transport systems. Some advocates supply based strategies involving addition of more road network as well as the efficient utilisation of existing ones via traffic management and control. Others advocate demand-based strategies whereby policies and measures that affect the pattern of people travelling demand are selected and implemented.

The traditional supply based strategy for tackling traffic congestion problems is to add more capacity through widening existing roads and constructing new ones, thus allowing for a more accessible road transport network and better traffic conditions. However, this approach has its limitations, in terms of absorbing an enormous amount of scarce financial and land resources, causing intrusion, and generally increasing the environmental, ecological, energy and safety hazards. Above all, this approach has frequently been reported to ultimately cause the generation of new, suppressed and latent demand. Because of the above limitations many cities have opted towards adopting policies and measures that enable the utilization of the existing road network space in the most optimum and efficient manner. Such strategy, known as Traffic Management and Control (TM&C) is
considered as a quick win short-term strategy. With technology and IT advancement such strategy is supported by Intelligent Traffic Systems tools and applications. The above package can be grouped under the heading “network supply and management strategies”.

In recent years, a paradigm change in thinking has emerged. This advocates demand-based strategies whereby policies and measures that affect the pattern of the travelling demand for people to travel are selected and implemented. Such measures can be grouped under Travel Demand Management (TDM) (known as Mobility Management in Europe) and Land Use Management (LUM) strategies. TDM can be defined as a set of programs/packages integrating a combination of policies, measures and actions with the objective of maximizing the people and freight moving capability of the transportation system. The primary purpose of TDM is to reduce the impact of travel on the transport system by improving the efficiency of demand for travel. This can be done by first making alternative premium high occupancy and non-motorized modes available. This should be accompanied by applying incentive, disincentive and other measures that are meant to modify car users’ behavior towards increasing car usage efficiency, shifting to other high occupancy and non-motorized transport modes, spreading the demand over time and space and reducing the amount and need for car travel.

TDM strategy should be also supported by Intelligent Traffic/Transport System tools and applications. TDM is considered a medium-term strategy. Of greater complexity is the development of long-term sustainable strategies. In this context, the other significant and deeply rooted demand management strategy, known as LUM strategy has as its primary purposes: to control the trip generating characteristics of land use and to promote land use patterns that reduce average trip lengths, encourage trip consolidation and promote land use patterns that support transit and non-motorized transport usage. Figure 5 demonstrates importance of the right integration of the above four strategies to mitigate traffic problems, enhance accessibility and mobility and hence achieve MISS TS.

### 5. CLASSIFICATION OF TDM POLICIES AND MEASURES

In nearly all cases, authorities across the world have concluded that the private car, especially when singly driven, should bear the brunt of meeting traffic reduction targets. Cars are the least efficient users of road and time space than most other competing passenger carrying vehicles. In the following sub-sections a comprehensive classification of TDM policies, measures and actions, in accordance with the above-stated objectives, is presented. TDM policies and measures can be classified into 4 main categories and 8 subclasses as follows:

- **Incentive policies and measures to encourage High Occupancy Vehicles (HOV), transit and non-motorized modes**, these are sub-classified into:
  - Policies and measures targeted towards increasing vehicles’ occupancies.
  - Policies and measures targeted to encourage the use of transit modes.
  - Policies and measures targeted towards increasing vehicles’ occupancies.
  - Supporting preferential treatment policies and measures.

- **Disincentive policies and measures to discourage Single Occupancy Vehicles (SOV) and Car trips**, these include:
  - Physical restraint measures.
  - Regulatory restraint measures.
  - Pricing restraint measures.

### 4. TRAVEL DEMAND MANAGEMENT STRATEGY: OBJECTIVES & INGREDIENTS

As previously stated, a TDM strategy should comprise incentive as well as disincentive policies, measures and actions. The objectives of TDM are summarized in Figure 6, while the main ingredients of TDM packages are depicted in Figure 7.

**Figure 5: Integrated Supply & Demand Based Strategies for Attaining MISS TS (Source: Abbas, 2012)**

**Figure 6: Main Objectives of TDM Strategy (Source: Abbas, 2015a)**

**Figure 7: Main Ingredients of Travel Demand Management Programs/Packages (Source: Abbas, 2012)**
5.1 INCREASING VEHICLE OCCUPANCY THROUGH RIDESHARING

The great majority of cars on our roads (particularly at peak hours) have a single occupant. A well-known TDM alternative is to increase the average occupancy of non-transit vehicles through ride sharing. If the public could be persuaded to share their cars with others, dramatic reductions in road usage would be attained. The two most common types of ride sharing are car pools and van pools. Carpooling is the sharing of a privately owned vehicle by a group of two or more riders. Vanpooling is midway between transit and carpooling in terms of convenience, flexibility and carrying capacity. In vanpooling, a set group of riders, often all working at the same place, shares a van provided either by an owner-operator, the employer or a third party. Vanpooling generally involves the use of an 8-15 passenger van, with driving done by one of the employees and the operating costs are partially paid by other riders through monthly fares. Both car and vanpooling require riders to have similar origin and destination points. Car and vanpooling rely heavily on the desirability to participate in such systems. It should be well organized to attract commuters into participation. Organization of such a ride share system is crucial to its success. An inventory of policies and measures to encourage ridesharing is depicted in figure 8.

5.2 ENCOURAGE SHIFT TO TRANSIT MODES

The smart response to problems of increasing car use is to encourage drivers to switch to alternative transit modes. To achieve a major shift from private to public transport requires massive investments to attain a comprehensively improved premium public transit system. A transit system developed taking into consideration the 7 R i.e. Right Product (Quality of Service) - Right Capacity - Right Place - Right Time - Right Fare - Right Information - Right Branding & Marketing. A classified inventory of TDM incentive policies/measures to encourage usage of transit modes is depicted in figure 9.

Some of the above measures that are meant to achieve competitive efficient transit services are detailed below:

- Reduction of wait time by increasing service frequency, modifying routes to reduce headways and improving transit transfer system
- Reduction of riding time by running buses in limited stop or express operation, constructing freeway or arterial bus lanes, Bus Rapid Transit Systems, implementing traffic signal preemption for buses, and restructuring routes to provide more direct services
- Fare management including implementing fare prepayment plan, providing fare passes, coordinating fare policies across service providers, and subsidizing fares (generally or selectively)
- Proper planning and design of transit facilities including stations, stops and terminals
- Provision of well designed, secure, well lit and implemented park & ride facilities. The park and ride concept should be more widely applied to both interurban and urban transit services operating from the outskirts of city centers to intercept drivers and provide transit services into areas suffering from serious congestion
- Integration of transit modes to encourage convenient intermodal transfer. A coordinated transit system linking bus stops with transit stations will allow additional opportunities to riders to reach their destinations without using automobiles
- Using telematics to improve the operation and management of public transport as well as to provide passengers with real time information both at stations and during journeys
- Transit usage financial incentives to be provided by government and/or employers/developers. These include free or low cost parking at park and ride locations, transit passes, transit allowances and subsidies, a guarantee for a free or subsidized ride home in case of employees working out of service hours or having to leave for family emergencies, other special promotions, etc

5.3 ENCOURAGE SHIFT TO NON-MOTORISED TRANSPORT MODES

Walking and cycling are termed non-motorised modes. Cycling may be faster than driving or public transport over shorter
Some of the above measures that are meant to encourage the use of these modes of travel include:

- Improvement of physical facilities i.e. sidewalks, bikeways and provision of more direct routings
- Construction of bike trails and pedestrian paths to connect with employment or commercial centres
- Ensuring continuity and clearness of routings - removing natural and built barriers that might discourage walking/cycling such as potholes, storm sewer inlets, etc.
- Provide waiting areas for transit riders in locations that do not impede pedestrian circulation
- Attractiveness and presence of interesting activities and pleasant views along walking routes
- Minimise pedestrian/vehicular conflicts by providing convenient, readily identifiable walkways/cycle tracks
- Phased traffic signals to accommodate pedestrian/cyclists movements. Prolonged waits at intersections can frustrate pedestrians/cyclists and discourage them from walking/cycling to their destination. Signal phasing should give priority to pedestrian/cycling movements, reduce their wait time, and minimise potential safety problems. Crosswalks should be clearly identified by techniques such as pavement marking, pavement variations, and signage

- Separation of vehicular and pedestrian/cycling crossings should be also considered. These include pedestrian grade separation facilities such as pedestrian bridges and tunnels
- Pedestrian pathways must be accessible to all, including elderly, people with disabilities, children. Design elements may include increased width for wheelchair passage and dropped curbs for access
- Modal connection improvements, to allow bicycling/walking to be used as a feeder mode
- Safe and secure, signed and well lit walkways and bikeways
- Incorporate buffers between roadways and sidewalks e.g. landscaping buffers, provision of setbacks, on street parking. Such provisions increase pedestrian safety, as well as protect pedestrians from incidents such as water/rubble splashes by passing vehicles
- Provision of bicycle parking, storage and locking facilities (shelters, storage racks and lockers)
- Shower and changing facilities at destinations
- On-site bicycle repair crew
- Allowing bikers to carry their bike with them via transit to the destination. Alternatively bike users could have a dedicated bike at both ends of a transit trip
- Allowing employees to travel between buildings of big employment centres using their bikes
- Marketing promotions and education programs
- Bike/walk financial incentives: These can be provided by government and/or employers. These include free or low cost bike, free or discounted equipment (shoes, bicycle helmets, etc), bike allowances, a guarantee for a free or subsidized ride home in case of employees working out of service hours or having to leave for family emergencies, other special promotions, etc.

5.4 PREFERENTIAL TREATMENT FOR RIDE SHARING/TRANSIT/NON-MOTORISED

Preferential treatment includes 4 forms namely High Occupancy Vehicle (HOV) Facilities, Transit ways, Segregated Sidewalks and Bikeways and other forms. These are covered below.

High Occupancy Vehicle (HOV) - is certain lanes or portions of a road, which are reserved for vehicles carrying a set minimum number of passengers, often three or four. By reducing travel time and making the amount of time needed to make a trip more predictable, HOV facilities encourage travelers to switch to higher occupancy modes of travel, such as buses, car or vanpooling. HOV facilities have been successfully operated in the USA. HOV facilities can be provided either by converting existing lanes or by adding extra lanes.

Transit Ways - represent a form of HOV facilities. These are means of controlling the use of road space so that public transport vehicles are segregated from general congested traffic conditions. One or more lanes of the road are reserved for the exclusive use of public transport, where automobiles

Figure 10: Classified Inventory of TDM Incentive Policies/Measures to Encourage Usage of Non-Motorised Transport Modes
and other traffic are banned. Transit ways are intended to free public transport modes from traffic congestion and give them a travel time advantage over private vehicles. All in all, transit way systems provide a low cost, high capacity, time saving mass transit system.

Segregated Sidewalks and Bikeways - are extremely essential for encouraging travelers to use such modes. This can be achieved by establishing:

- Segregated walkways where cconsideration given to establishing a network of walkways linking various portions of the community as well as walkways incorporated into all new developments
- Segregated cycle routes i.e. cconsideration should be given to establishing a network of bikeways that would link the various portions of the community
- Area pedestrianisation is another form of access control, which has serious implications for the retail distribution sector. It incorporates severe restrictions on access to shops by delivery vehicles; however the social and environmental benefits of managing the freight demand is considerable

Other Preferential Treatment Measures including

- Traffic Signal Preemption for HOV and Transit Buses, where telematics can be used to give buses and HOVs priority over other vehicles at signals
- HOV preferential (free or reduced) fares/tolls
- HOV exclusive parking facilities
- HOV preferential (free or reduced) parking fees

A classified inventory of TDM preferential treatment policies and measures to encourage usage of HOV, transit and non-motorized transport modes is displayed in figure 11.

5.5 PREFERENTIAL TREATMENT FOR RIDESHARING/TRANSIT/NON-MOTORISED

The main aim of disincentive policies and measures is to make car travel less attractive by increasing the time, cost and general hassle of driving in the course of the journey as well as of parking at both ends. This is expected to discourage and decrease SOV & Car Trips. Three broad mechanisms by which moving road traffic can be influenced, namely:

1. Physical measures, such as limiting junction or link capacity
2. Regulatory measures, such as restrictions on access for certain groups
3. Pricing measures, through the introduction of some form of charging mechanism for road use

Classified inventories of TDM disincentive policies and measures to discourage traffic in general and SOV in particular during journeys as well as during parking at origins and destinations are shown in figure 12. These are further detailed and discussed below.

Physical Restraints on Moving Traffic (Traffic Collars or Throats) - Here road capacity can be restricted in one of two ways, either through limiting space (e.g. by narrowing the carriageway or re-allocating part of it for a bus lane), or by time rationing (using traffic signals to impose delays). In practice, the two are commonly used in combination, when bus lanes are provided and buses are given priority to pass traffic signals through traffic signal pre-emption. The main implementation problem is to find enough space on the road system to store the queuing vehicles, without fouling major junctions and unrelated local or cross movements.

Physical Restraints on Moving Traffic (Traffic Cells and Mazes) - With a traffic maze, movement through an area is possible, but only by using an indirect routing that makes it an unattractive option for through traffic. This has been used in some residential areas in the Netherlands and UK. On the other hand, traffic cells are usually applied in city centres sub-dividing the area inside a ring road, allowing entry/exit from the ring road side only. In Gothenburg (Sweden) reductions of 50% were observed on some roads that were previously main routes through the central area.

Physical Restraints on Moving Traffic (Traffic Calming Measures) - A variety of measures can be used to physically reduce traffic speeds, such as speed humps or rumbles, chicanes, gateways, islands, built out, overrun area, roundabouts, junction off-sets, pinch points, etc. In general, the purpose of these measures is to ‘tame’ rather than restrain traffic, by reducing speeds, so that motorised and non-motorised traffic are more compatible. Most of these measures have been applied in residential areas in the Netherlands (known as the Woonerf), Germany and the UK.

![Figure 11: Classified Inventory of TDM Preferential Treatment Policies/Measures to Encourage Usage of HOV, Transit and Non-Motorized Transport Modes](image)

![Figure 12: Classified Inventory of TDM Disincentive Policies/Measures to Discourage Traffic/SOV During Journeys](image)
Although the above physical restraint measures can lead to improvements in road safety and environmental conditions within the treated areas, none of these physical restrictions appear by themselves to lead to significant reductions in the use of motor vehicles.

Physical Restraints on Parking - The average car is parked for over 23 hours of each day, so that the provision of parking is a major factor both in the ownership and use of private cars. On street parking usually takes place on both sides of the road. This leads to a reduction of the number of lanes for moving vehicles. This might be relatively acceptable in residential areas where traffic intensity and speeds are low, and parking is a necessity. However, most of work sites are located on district or primary distributors meant to allow through traffic movement and where on street parking should be banned or severely limited. Localities set codes with parking requirements for developments. Requirements oblige developers to provide a certain amount of parking within their developments. Parking requirements vary with the type of land use. Ease of parking at the destination is considered as the major influence on car use. Parking provision can be physically controlled by restricting the number of spaces provided. This includes setting minimum and maximum numbers of spaces provided, instituting on street controls such as parking metres. Limiting number of parking spaces has the primary effect of increasing inconvenience associated with driving, where finding an empty parking space becomes extremely difficult.

Regulatory Restraints on Moving Traffic (Restrictions on Vehicle Types) - Many cities may apply link or area bans to heavy goods vehicles, but it is more difficult to differentiate between the various types of car or light van. The only means by which this has been achieved in a few cities is on the basis of the last number on the vehicle licence plate. Athens has an odd-even licence plate restriction operating on alternate weekdays in the central area within the inner ring road. Significant reductions in car traffic levels was observed, though nothing like the theoretical reduction of 50%, due to people switching trips to unaffected days or purchasing a second car.

Regulatory Restraints on Moving Traffic (Entry by Permit) - Here cars display a permit allowing eligible occupants access to the restricted area, usually based on local association (for example, a resident, hotel guest, local business owner, etc.) or a more general exemption (e.g. disabled occupant). With the advance of technology, magnetic or electronic cards can be issued to exempt users, who then gain entry to the designated area by triggering a barrier or bollard; number plate recognition is also an option, obviating the need for cards. There can be very major boundary problems just outside the regulated area. This could take the form of congestion and heavy on-street parking, as people by-pass the restricted area, or bring their cars as close as they can to the city centre.

Regulatory Restraints on Parking - Available parking spaces can be regulated by one of three ways:
- Limiting the types of vehicle that can park
- Limiting the times of day that parking is permitted
- Limiting the maximum duration of parking that is permitted

Pricing Restraints on Moving Traffic - Aside from its revenue generating potential, road pricing is considered as a more realistic longer-term solution to urban traffic problems. Drivers should pay fees, which reflect the full costs that their driving imposes on society. Road pricing, where road users are charged differential rates by time of day and location depending on the level of congestion, is considered as one of the most effective TDM measures. In principle, it could be used to cap traffic at a predetermined level if charges were raised sufficiently. By charging motorists prices that represent the cost they create by using a particular road, individual drivers will react to these costs in one of four ways: 1- Accepting charges, 2- Shifting to another mode, 3- Going to another route, 4- Foregoing the trip.

Introduction of urban road pricing requires a number of decisions to be taken, about who to charge, when and where to charge, and on what basis to charge users. Payment by car drivers for use of the road network could be based on a number of principles:
- Point charges, at links or junctions
- Cordon or boundary charges
- Charges for driving within a designated area
- Length-based charges (measured in terms of time or distance)
- Externality-based charges (based on congestion caused, emissions, etc.)

Pricing Restraints on Parking - Policies, which control the price of parking in urban areas, can influence the number of solo commuters. Both government and employers can implement parking programs. The government can change parking pricing policy by taxing private parking lots, increasing parking fees for solo drivers, reducing parking fees for ride sharers. Employers can change parking pricing policy by removing employer provided parking subsidies and giving discounts to ride sharers. Parking taxes or surcharges are especially effective in creating a cost differential between driving alone and other alternative modes, hence encouraging drivers to seek these alternatives. All in all, parking pricing is considered as one of the most effective TDM measures for reducing the number of SOV trips.

5.6 OTHER GOVERNMENT RELATED DISINCENTIVES

Governments have the power to exert pressures on people wanting to own private cars and use them. A classified inventory of other government related TDM disincentive policies and measures to discourage traffic in general and SOV in particular is depicted in figure 13. These are further detailed and discussed below.

Some of the government control forms include:
- Increase fuel surcharges. It has to be noted that the demand for fuel is relatively inelastic and the duty change needed to have an impact on road use could be well in excess of increases. The previous statement might be truer in developing countries where fuel prices are considered to be relatively low. Any fuel price increase policy would have to take into consideration that such increases would add to the costs of road transport and would feed through into higher prices for carried goods.
• Flextime: where employees are allowed to arrive/leave work at any point during a specified block of time, which spreads peak period demand over a longer time period
• Staggered work hours: where different groups of employees report to/leave work at different times, i.e. similar to flextime but more organized

Employees and employers both find alternative work hours attractive not only because these open up new transportation options, but also because these help improve the split between work and family responsibilities, managing shopping, day care and other chores. Absenteeism, tardiness and turnover may be reduced by variable work hour programs.

**Goods Movement Management**
- Trucks are a special element of urban traffic. Goods movement management attempts to better plan the time and location of truck pick-ups and deliveries in urban areas so as these could take place at off peak times and locations. Goods movement management actions include:
  - Peak period truck bans
  - Night shipping and receiving
  - Storage areas, picking and receiving points to be located at places which has spare road capacities
  - Physical improvement of storage areas and picking and receiving points minimising their traffic impacts on surrounding areas.

5.7 SHIFTING TRIPS TO TIMES AND PLACES WITH SPARE NETWORK CAPACITY

Several forms of policies and measures can be used to shift trips to times and places with spare network capacity. A classified inventory of TDM peak spreading policies and measures is shown in figure 14.

**Variable Work Hours**
- One of the principal causes of peak hour congestion is the fact that most people start and finish work at approximately the same time each day. Work hour policies established by employers govern the time period in which employees travel to and from work. Introducing time differentials into the starting and finishing work times spread peak demand in a more uniform pattern. Such policies influence the volume of employees traveling during peak periods. Two main types of variable work hours can be used to attain temporal peak spreading, namely:

- Flextime: where employees are allowed to arrive/leave work at any point during a specified block of time, which spreads peak period demand over a longer time period
- Staggered work hours: where different groups of employees report to/leave work at different times, i.e. similar to flextime but more organized

Reducing the need to travel without compromising any economic or social benefits is a growing trend particularly with the advancement of communication technologies and mobile applications. A classified inventory of TDM trip reduction policies and measures is shown in figure 15. These are further detailed and discussed below.

**Work At Home Alternative (Teleworking/Telecommuting)**
- In order to reduce the number of work trips, it could be proposed to carry out some of the work duties at home for a few days per week instead of doing all job tasks at the work place. This is achieved by providing substitute tele-services facilities, which can be accessed by employees from their home or from satellite working centers close to their homes. This is one of the promising forms of TDM, known as ‘teleworking’.

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**Figure 13: Classified Inventory of Other Government Related TDM Disincentive Policies/Measures to Discourage Traffic/SOV**

**Figure 14: Classified Inventory of TDM Peak Spreading Policies and Measures**

**Figure 15: Classified Inventory of TDM Trip Reduction Policies/Measures**
Shop At Home Alternative (Teleshopping) - Teleshopping is the use of computer or television based services to purchase a full range of goods, including food, fashion goods, house wares, gift items, etc. Consumers view and select goods, order products to be delivered and make payments by direct debit or credit cards, etc. It is typically performed using television receiver and telephone. Tele-shopping is becoming very common in the USA and Europe.

Teleeducation (Telelearning) - Teleeducation or distance learning involves the use of satellite, cable television systems to transmit classroom instructions to one or more remote locations (classrooms, homes, etc.) This could involve receipt of assignments/exams, submission of homework, access to electronic libraries, face to face counselling and participation in class discussions. Teleeducation minimises commuting by students and professors and can serve students in remote locations and those physically unable to appear on campus. In the USA, elements of teleeducation have entered the university generally as students increasingly collect and submit assignments and search library catalogues and databases from their home computers.

Teleconferencing - There is also the potential to conduct meetings via tele-video links, known as tele-conferencing, which could also reduce daytime travel. Efforts have been reported in congested areas like New York that some meetings and in person conferences are conducted with telephone conferences and video presentations. Doctors and other health care professionals can gain instant access to patient’s medical histories and visual records, simultaneously viewing information on screen and discussing it.

Telebanking - Telebanking involves the use of a computer and modem and/or touch tone phone to perform financial transactions such as making electronic deposits, obtaining access to balance, transfer of funds between accounts, bill payment, account information, electronic check book balancing, obtaining automated financial services, etc. Telebanking is currently supplementing the Automated Teller Machine (ATM)

Telemedicine (Telediagnosis) - Telemedicine can involve medical consultation, diagnosis, and monitoring. Patients and doctors at remote locations can be engaged in a face-to-face counselling. Telemedicine involves direct transmission of data to the medical computer for automatic analysis. Sophisticated medical imaging (MRI, CAT, X-ray) can be also transmitted. Telemetric devices that monitor heart rate and other vital signs can be instantaneously transmitted with other patient’s information to a doctor at another location.

Telejustice & Televoting - Deposition and arraignments can be handled through video conferencing links between the courthouse and prison, thus avoiding the need to transfer prisoners. Tele-voting in the sense of casting a ballot for a candidate for office has not yet become a political reality.

Compressed Work Week - Such scheme allows employees to work one day less, however this is being compensated by longer hours during other working days. Typically, a five days working week would become a four days working week with ten working hours per day instead of eight. This reduces weekly working trips of each employee participating in such a scheme by at least two trips (going to and coming back from work). In addition to reduction of one working day, another outcome of this scheme is the early off-peak arrivals and late off peak departures built into the ten-hour days.

Encourage Organized Transport for Schools - Whilst the need for children to get to and from school safely must never be questioned, a structured school public transport system available to the maximum number of school children would do much to alleviate pressure on urban roads. Bus school transport provides a safe and reliable alternative to the family car. Such services must be encouraged and widely promoted. Such services must be accompanied by adequate off road parking facilities for buses. Car parking in the vicinity of schools should be better managed as to lessen the danger of pedestrians and other road users as well as to lessen the impact on traffic congestion.

Home Delivery Services - There has been a growing trend towards home deliveries from major retailers. By delivering direct to residential areas the retailer avoids highly congested streets, giving a net benefit in terms of less town center deliveries. In addition, retailers can choose to deliver at times when roads are less congested.

6. CONCLUSION

MENA cities as many other cities in the world are aspiring to achieve the MISS TS vision. Attaining such a vision requires a comprehensive, holistic approach combining supply and demand based strategies/policies/initiatives/measures/tools in a smart fashion. Towards this end this paper briefly discussed strategies available including TDM, LUM and ITS. The paper demonstrated the importance of the integration of such strategies and others in order to enhance accessibility and mobility, and mitigate traffic problems. The core of the paper was to develop a comprehensive classification of policies/measures/actions falling under TDM strategy to be used for attaining MISS TS. Such a transport system is meant to achieve the necessary levels of mobility and accessibility, while taking into consideration the relief of transport and traffic-related problems.

It is recognized that the intensity of traffic problems could be minimized if the criterion of mobility was targeted to the movement of people rather than being oriented to the movement of vehicles. Hence a truly smart sustainable transport system is one that provides efficient environment friendly and safe alternatives to the traveler and then reinforces the travel decision by implementing incentives and disincentives that are clearly perceived by the individual making the decision to travel. This paper advocates the development of a multimodal integrated smart and sustainable transport strategy. Such strategy would be composed, at the core and among others, of TDM & LUM policies/initiatives/measures/actions. The main ingredients for such strategy should be directed towards:

- Increasing vehicle occupancy through ridesharing
- Encouraging shift to transit modes
- Encouraging shift to non-motorized transport modes
• Exercising preferential treatment for ridesharing, transit and non-motorized transport
• Discouraging traffic in general and SOV in particular
• Shifting trips to times and places with spare network capacity
• Reducing need to travel
• Reducing average trip lengths
• Adopting LUM conducive to usage of transit modes
• Adopting LUM conducive to usage of non-motorized transport modes

Such strategy cannot be a random combination of TDM and LUM tools. Which measures are selected will depend on the type and intensity of the traffic problems at hand as well as on the environment in which these will be implemented. In this context, it is crucial to realize the importance of conducting transport planning within the general framework of sustainable development. Finally, it has to be noted that TDM approaches are medium term solutions to traffic problems. The long-term solution to traffic problems lies in making land use changes, which also is the hardest to implement. Structuring communities so that people live closer to their jobs and they do not need to rely heavily on their cars for other activities is the surest way to attain the MISS TS vision.

REFERENCES
INVESTMENT IN AND PRIORITIZATION OF PUBLIC TRANSPORT IN SAUDI ARABIA

By Mr. Abdulaziz Saad Alsalem - Business Sector Director - SAPTCO

Saudi Arabia is one of the largest countries in the Middle East & North Africa (MENA) region, comprising some regionally important cities like Riyadh the Saudi capital, Jeddah the economic gateway & commercial outlet on the Red Sea coast, Makkah & Madina where the two holy mosques are located and visited by pilgrims coming from all over the world and Dammam Metropolitan Area, the major source of petroleum & transformative industries and economic outlet on the Arabian Gulf coast. However, Saudi Arabia is suffering from lack of public transport in its urban areas. Although there are very limited bus services running in some cities, they do not constitute resilient public transport systems or networks.

In 2015, the total losses due to road accidents in Saudi Arabia exceeded 5.3 billion dollars with more than 7,000 deaths (the figure represents deaths on site only and does not include those who die in the hospitals later on). Besides, the car ownership rate in Saudi Arabia is excessively high. For instance, the ownership rate in Riyadh is 1.7 cars per individual which is notably high compared to other countries. Additionally, the share of the transportation sector from the total energy consumed in the country is 23%. So, if consumption keeps growing by the current accelerating rate, Saudi Arabia will consume half of the energy it produces 10 years from now.

Riyadh is the biggest Saudi city in terms of geographical area and population density. Its annual demographic growth rate is 4.5%, one of the highly growing metropolitans in the world. At the moment it is inhabited by nearly 6 million inhabitants generating 7.4 million daily trips. Out of this huge traffic volume, public transport acquires 2% only for its market share.

In 2012, the public transport project for Riyadh was approved (King Abdulaziz public transport project) and mid 2013 marked the official kickoff of implementation. The project consists of two components, Riyadh Metro and Riyadh Bus networks. Riyadh Metro comprises 6 metro lines with a total length of 176 kilometers, 85 stations and 190 trains. The number of trains can be increased to 338 in response to the increase in demand. Upon inauguration, the project will start with a daily capacity of 1.16 million passengers then increases to a maximum of 3.6 million passengers 10 years afterwards. Driverless trains will be used to run this project which is the biggest public transport project to be constructed all at one time. 30% of the project has already been completed.

Riyadh Bus on the other hand will be operate a total of 1,000 buses of different types and capacities. The network comprises 24 lines with a total length of 1,150 kilometers and 6,730 bus stops/stations. The bus network will be integrated with the metro network to create a comprehensive integrated public transport system which will make a drastic change in the life style of the capital city.

The public transport project for Jeddah has also been approved and the planning & network design stage completed, so the tendering process might start soon. The project consists of 3 metro lines and one tramway with a total length of 146 kilometers and 84 stations. A number of 816 buses will be used to operate Jeddah’s bus network with a total length of 750 kilometers and 2,950 bus stops/stations.
The public transport project for holy Makkah has also been approved and coordination with the Holy Mosque’s expansion projects will be made prior to the kickoff of the public transport project implementation. The project comprises 4 metro lines with a total length of 133 kilometers and 66 stations while 500 peak buses will be used to operate 12 lines bus network with a total length of 300 kilometers.

In Madinah, the design of a public transport plan was approved including 3 metro lines with a total length of 95 kilometers and 70 stations. The project includes also 11 bus lines with a total length of 215 kilometers.

In Dammam Metropolitan Area the design of the public transport plan was also approved including 2 LRT lines with a total length of 86 kilometers and 54 stations. Besides, more than 350 buses will be used to operate the bus network with a total length of 394 kilometers.

All these projects will constitute a quantum leap for Saudi Arabia and will impact positively by reducing fuel consumption, environmental hazards and traffic accidents in the country.
THE CURRENT STATE OF PUBLIC TRANSPORT IN OMAN

The current rebranding of the public transport services in Oman certainly shows the intention of transport authorities to revamp the public transport infrastructure and provide better services to the people. However, before discussing the Mwaslat case, it would be important for the readers to gain a holistic perspective, and to first understand the current state of public transport and the related macro environmental forces affecting it. This section gives a brief account of the state of affairs in Oman.

Currently, the presence of public transport services is very low in Oman and is limited mainly to Muscat. Other regions in Oman lack public transport. People in these regions rely largely on shared taxis or their private cars, and this causes inconvenience, traffic jams, accidents, and high individual expenses on transport. Furthermore, the taxi services in Oman also lack on certain aspects. Taxi operations are largely unorganized and unregulated. Most of the taxi services are rendered on an individual basis. Although taxis meet the basic mobility needs as the last alternative, their services, availability, and the prices are not guaranteed. There lies an expectation gap between drivers and the customers, who, at times, hold each other accountable for the gap in the service delivery. Media reports are also indicative of a tussle between Airport and ordinary taxis (blue and orange taxis as they are known locally), both claiming for a favorable demarcation of their operational areas and boundaries\(^1\). So far, people in Oman have not experienced other (non-bus) alternative modes of public transport such as trams, mono-rails, light rails, and heavy rail. However, the $20 billion GCC railway network project is currently under implementation and is expected to be ready by 2020\(^2\). Some ferry services offer limited public transport services to the people who commute between the mainland and the islands.

Over the past few years many factors have caused a shift towards public transport: rapid population growth, regular traffic jams, accidents on road, the increase in the fuel prices, the pressure from the economic slowdown, and increased cost of living. It is likely that expatriate population is going to use public transport more often than the natives. However, the natives who are used to taxis are likely to form the ‘early majority’ for using public transport, leaving behind females who eventually will be the laggards, given some socio-cultural issues. Earlier research informs that people’s dependence on private cars and their use of private cars have affected the development of public transport in the country. These issues can be confronted on the premise of a study which observes that whilst reducing car usage contributes to social cohesion, reducing car dependency contributes to social inclusion\(^3\). The provision of public transport services reinvigorates the concept of urban citizenship and common public spaces through social cohesion and social inclusion\(^4\). Development and marketing of decent public transport services in Oman is important also from the perspective of traffic accidents, which have become a major concern to the society. There has been no significant improvement in the number of accidents and associated fatalities, in spite of using safer vehicles, safety devices, and the road safety measures.
REBRANDING ONTC

Rebranding, as a strategy, has been commonly used for improving the marketing of products and services. Business organizations globally have pursued corporate rebranding to enhance brand relevance, operational efficiency, and profits. Oman too has rebranded recently its 1972 born state public transport brand ONTC (Oman National Transport Company) to ‘Mwasalat’. The once popular logo depicting the national animal of Oman, the Arabian oryx has been replaced by an abstract piece of art, which appears as a network of roads. There is a hue of red in all the new communications – the brand, the logo, and the color of the bus, all appear red. The website of the company has been revamped where a punchline in bold reads ‘Sit back and enjoy the ride! Mwasalat keeps you moving.’ The multipoint mission statement of the company as expressed in the new website aims to attract and encourage people to use public transport, by offering an efficient world-class infrastructure, amid safe and environmentally friendly services for achieving a better land connectivity and reduced congestion.5

During this rebranding, the company resorted to promotional pricing policy in the beginning to attract the transit seekers and patronize their subscription to the services. For this purpose, the capital city Muscat was divided into three travel zones and a free ridership was offered to public until 30th November 2015. The token prices of 100, 200, and 300 baizas were introduced subsequently from 1st of December for transiting across a single, two, and three zones, respectively. This token pricing was changed to normal pricing – 200, 300, and 500 baiza, respectively from the beginning of the February 2016. According to a media report, the residents welcomed this public transport revamp6. Altogether, this brings some excitement to stakeholders.

Earlier, ONTC’s visibility as a public transport provider was fading, as it limited its operations to the capital city and a few long haul destinations such as Dubai in the north and Salalah in the south. The company did not have many competitors in Muscat; however, it faced tough competition on long distance routes, where companies like the Gulf Transportation Company, Salalah Line and Al Ghazal Transportation had been highly responsive to the surge in demands arising from time to time.7 However, just believing that a mere rebranding will solve all the mobility needs and travel ordeals of public would be a mere fallacy.

FLEET EXPANSION, NEW INVESTMENTS AND NEW PLANS

The current fleet of Mwasalat has 574 vehicles comprising of mini buses, low floor buses, long distance coaches, and super luxury coaches. The fleet is supported by a network of 11 branch offices and 13 agencies and 700 staff - 95 per cent of them are Omani.

The new expansion features a fleet of 40 brand new VDL buses on the five different routes, plying between 6 am to 10 pm, in headways varying between 15 to 20 minutes.8 Additional routes are expected to be introduced in 2016. More than 60 bus stops have been planned to make commuting easier along a new main route connecting Ruwi and Seeb – where most of the traffic flows. An investment of approximately 7 million Omani Rials have been made to purchase new buses equipped with monitoring cameras for safety and accessibility features for physically disabled riders.

There is also news that an ambitious public transport master plan is currently under development. According to media sources, the plan aims to identify the routes, assess the demand, and make proposals for the new services.9 A Spanish consulting firm INECO has been commissioned by the government to create this master plan for a bus and light-rail network in Muscat, and also to look at an overhaul of the taxi regulations in Oman.10,11

THE WAY FORWARD

As mentioned earlier, rebranding may not be enough. To take advantage of these positive developments, Mwasalat will have to focus on the core components that drive it. The supply of complete information related to the bus schedule, travel frequency, prices, online booking and purchase, mobile apps for routes and transactions, electronic ticketing machines, establishment of help lines would be the most sought after requirements of the transit seekers. The new website of Mwasalat is still under development and is not complete in this context. A commitment on the part of employees to ensure the delivery of the brand promise will be necessary to build people’s trust in the initial services, which will require further investments in different modes, their integration, and better services.

Additionally, Mwasalat would need support from other major stakeholders such as ministries, municipalities, private transport operators, and taxi unions in offering a convenient mix of integrated services to the customers. The net effect of rebranding would require a focus on the quality and efficiency of services on one hand and the building of trust on the other. According to Millar et al. (2014) rebranding efforts need adequate research, a differentiated value offer, and stakeholder's buy-ins where a phased approach involving development of brand understanding, internal branding activities, stakeholder coordination, and an integrated marketing programme is required to succeed.12

Oman needs to ensure an all pervasive and integrated public transport system to attract and retain transit seekers who otherwise perceive public transport services negatively. Although the environmental forces such as the rise in fuel prices, road traffic accidents, and traffic congestion increase public transport use, offering an integrated public transport mix ensuring end to end connectivity is crucial to be nurtured and cherished as a part of public policy. This would not only need awareness creation measures to motivate people to experience and adopt public transport, but also several backend processes related to investments), the development of infrastructure, regulation of different modes, provisions of information, communication and payment mechanisms, and their seamless connectivity and interoperability with separate but coherent master plans for different cities.
Oman has a mature system of urban planning. However, the integration of public transport masterplan in the process has been a missing link so far. Accommodation of public spaces for vehicles in large facilities such as parking, schools, hospitals, and hypermarkets is important during land acquisition and land use for economic and transit related efficiencies. Increasingly important is to improve the walkability index, which is poor in the GCC states. One of the most formidable challenges to this will be the hot weather conditions, which will demand additional measures such as AC bus stops. Just offering bus services might not help, unless the issue of walkability is considered in offering smart urban solutions. Public transport masterplans are to be developed for all the cities and to be linked to create a well-integrated, multimodal, and interoperable infrastructure for a seamless mobility.

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5. See http://mwasalat.om/en-us/
The cities of the MENA region are facing several challenges related to transport issues that directly affect quality of life of urban dwellers. The level of urban public transport development is heterogenic in the region, mainly due to the disparities in availability of financial and natural resources as well in level of political stability among MENA cities. However, all cities of the MENA region suffer from the same negative externalities of a continuously increasing traffic congestion, air pollution and traffic fatalities (El-Geneidy et al 2013).

In order to overcome these challenges it is crucial to develop and implement a strategic urban and transport development plan in line with the local challenges and the specific mobility needs and preferences of the population. Four main steps define the process for the implementation of an appropriate strategy: (1) conduct a comprehensive analysis of the current transport supply and demand, (2) define action plans to reach the objectives fixed by the strategy, (3) implement measures to achieve the action plans and (4) monitor and evaluate the impacts of the implemented measures. Analysis of reliable data is crucial throughout the entire process.

This article discusses the current use of Household Travel Surveys in MENA cities as well as the potential to strengthen user-oriented services in the MENA cities based on “Household Travel Survey” data analysis. The diverse aspects mentioned in this article are the first insights on challenges and opportunities for data collection and analysis in the cities of the MENA region and will be the focus of future in-depth research activities of the MENA Center for Transport Excellence.

USE OF TECHNOLOGY IS AN OPPORTUNITY TO COLLECT SPECIFIC AND REAL-TIME TRANSPORT DATA

A large panel of tools are available for urban transport data collection. For public transport, the emergence of electronic boarding systems in MENA cities is a great opportunity to continuously collect and analyze data in order to quantify the flow of passengers on each public transport line, station and at every time of day throughout the year. Public transport vehicles equipped with GPS enables collection of data on vehicle trips and kilometers as well as the management of traffic problems in real-time, reducing delays. Concerning road traffic, some tools such as toll systems and control cameras are a source of data and allow the estimation and control of traffic flow in urban areas. The widespread penetration of smartphone technology enables individual tracking, in an anonymous way, and is currently one of the most innovative tools to collect real-time transport data and therefore contribute to improve demand management in real-time (OECD/ITF 2015). In Casablanca, new technologies are used to collect data and improve public transport management and strategic development, as discussed in the article of Stephen Webb “Big Data and Public Transport” (pg42).

In Egypt, a conceptual model for the establishment of an Intelligent Transportation Data Center (EGY-ITrans) is in discussion with the aim at using data collected through new technology and at providing real-time information to users (see the article of Dr. Ahmed Mosa “An Innovative Framework for an Intelligent Transportation Data Center in Egypt” (pg27).
HOUSEHOLD TRAVEL SURVEYS (HTS) AS TOOL TO UNDERSTAND INDIVIDUAL MOBILITY PATTERNS AND PREFERENCES

Whereas technology enables the collection of “Key Performance Indicators” for public transport and real-time traffic flow in cities, these data do not provide knowledge on socio-economic and demographic characteristics of the users; they also do not provide the motivation underlying the modal choice of urban dwellers. Mobility patterns and preferences of individuals and households according to their age, social level and financial situation are crucial information to identify the typical profile of public transport users and develop a public transport strategy that will respond to the specific expectations of the diverse groups of the society. Household Travel Surveys (HTS) are the most accurate method used worldwide to understand the current travel patterns and behaviors of the residents of a city in a comprehensive way and develop strategies in line with societal changes (Griffiths et al. 2013).

HTS entails gathering data from a representative sample of the population in defined geographic zones of an urban area, extrapolating this data for the entire population of an urban area. The survey collects valuable data related to socio-demographic and economic characteristics of households, individual (age, income, education, etc.) and their mobility patterns (modal choice, time, distance travelled, purposes of the travel) and mobility tools (car ownership, public transport abonnement, etc.). The design of HTS can be cross-sectional – a single sample of households or individuals complete a survey during a single period of time – or longitudinal – same sample of households or individuals complete survey for multiple periods of time. The latter enables the analysis of changes in behavior of same units due to changes in environment and other factors (Bradley 2009).

Several methods are used to collect data: face-to-face personal interviews, postal surveys, telephone surveys and internet surveys. For collecting data on travel patterns, randomly selected individuals/households are asked to record all travel and activities conducted during an assigned 1- to 2-day period (survey diaries) including start time, travel time, trip length, origin, destination, travel mode, trip purpose, and vehicle occupancy of each trip. The emergence of new technology can facilitate data collection and new tools such as the use of GPS support a more accurate recording of daily travel patterns (Griffiths et al 2013, Guy and Fricker 2005).

RESTRICTIVE USE OF THE DATA AND LOW ACCESSIBILITY TO RAW DATA IN THE MENA REGION

Several MENA cities are conducted HTS. However, the frequency and quality of data collected is uneven due to the diverse development advancements and political stabilities (El Geneidy et al. 2013). Table 1 summarized for some MENA cities the frequency, objectives and methods of HTS. It appears that all local transport authorities conduct HTS with the two main objectives of building traffic and transport models and developing transport development strategies.

However, the analysis of the data collected in HTS could be profitable for diverse purposes and for the development and promotion of public transport on different levels: for research on mobility trends, for comparison of transport demand between cities and for public transport marketing strategies. It is especially interesting to use the data collected in the HTS for identifying current users of public transport by their socio-economic characteristics, and identifying which modes are preferred for which purposes and therefore target campaigns to reach the current users and potential future public transport users.

Nowadays, the sharing and dissemination of data in the MENA region is inadequate due to factors that limit the easy exchange of data: complexity of organizational governmental entities and reliability of the data due to diverse methods of collection. Although HTSs are conducted, the data remains mostly under the ownership of local authorities and access to the raw data are limited for external entities, such as academia, researchers and the private sector. Some reports highlighting the main findings of the analysis of the surveys are sometimes available. Nevertheless, specific and in-depth analysis of the results on socio-economic characteristics of households or individuals in correlation with the mobility patterns are not easily accessible.

Who are public transport users in the MENA cities? What are the mobility needs and expectations of the diverse socio-economic groups in the cities? For several MENA cities, these questions remain unanswered. Data should be collected by local transport authorities to find out.

International best practice shows that most of cities collecting data through HTS are using an “open data” policy to give free data access to the public. The Sydney Greater Metropolitan Area is one of the best examples for HTS conduction and communication. HTS are conducted yearly by the Bureau of Transport Statistics within the Planning and Programs Division of Transport for North South Wales (Australian state, with Sydney as its capital). On their website, all information and results related to the HTS are available: method for the data collection, process for the validation and preparation of the data, results of the analysis. Furthermore, raw data are freely available to everyone at any time (NSW Government).
One of the main challenges for comprehensive data collection is to define the survey area. Traffic in one city is generated by the residents of the city itself as well as by commuters from/to neighboring cities. This is the case for the neighbor cities Dubai and Sharjah: a relevant share of the population of Sharjah is commuting daily between the two Emirates. Some information on these commuters are already included in the HTS of Dubai. However, it will be more accurate to collect data with a common methodology for the two neighbor cities for a comprehensive understanding of the mobility patterns of commuters between Sharjah and Dubai. Therefore, one of the most important criteria of the HTS is to define the survey areas: either a single municipality, a metropolitan region or co-agglomerations.

It is crucial to carefully design HTS in order to collect valuable data that can be compared to other cities and useful for the diverse transport stakeholders. HTS aims at gathering data that reflects current trends, and new alternative modes have to be taken into account. The emergence of cycling in some of the cities of the MENA region could be measured by including biking as well as walking as two differentiated modes of transport (instead of as two differentiated modes of transport (instead of as walking as two differentiated modes of transport (instead of as walking as two differentiated modes of transport (instead of as walking as two differentiated modes of transport (instead of as walking as two differentiated modes of transport (instead of as walking)).

It is therefore crucial to include biking as well as walking as two differentiated modes of transport (instead of collecting data on “non-motorised trips”) in HTS design in order to assess the impact of the applied strategy and understand...
better the current significance and potential of walking and biking in the MENA region. Furthermore, the emergence of alternative transport modes in urban areas of the MENA region, such as bike-sharing and car-sharing contribute to increase the amount of intermodal trips: use of more than one modes of transport during a single trip. HTS should reflect these new mobility patterns that are currently difficult to quantify and understand for transport planners, operators and authorities (Kagerbauer et al 2015).

MENA CTE AS A CATALYST FOR GATHERING DATA AND FOR ENCOURAGING USERS-ORIENTED PUBLIC TRANSPORT SERVICES

In its current research program, the MENA Center for Transport Excellence (CTE) is working on encouraging local authorities and public transport operators to share the travel data available with the aim at creating a database for the MENA region. Several objectives are underlying the daily work of MENA CTE: understanding the current transport supply and demand in the cities of the MENA region, identifying best practices and on-going trends in the MENA region and identify the strategies that will contribute to encourage the use of public transport by implementing measures to reach better current and future public transport users. Access to data is an absolute condition to successfully generate new knowledge and support local actors to develop sustainable and user-oriented public transport system in the MENA region.

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Prolonged daily periods of road traffic congestion waste time and money and degrade both the environment and our quality of life. The population of Egypt is growing by 1 to 1.5 million people per year and is expected to reach 80 million by 2015. Together with the growing economy, this is inevitably putting more pressure on the country’s transportation system. The problems are particularly acute in the Greater Cairo area, one of the world’s mega-cities with a population of more than 17 million and where the demand for mobility has greatly outpaced the capacity of the public transportation system to cope. The gap has been primarily filled with private owned and operated shared taxis (so called informal transport) and the use of private cars. Consequently, congestion has become a major problem and the air quality has deteriorated to an alarming level. By continuing the current baseline development with the increasing population and the increasing use of private vehicles and shared taxis at the expense of more efficient public transport modes, the average trip speed of all the modes will drop from current 19.0 km/h to 9.6 km/h in 2015 and the average commuting time will increase from the current 37 minutes to 150 minutes in 2015. The estimated value of time loss due to traffic congestion is about 9.5 billion L.E./year. In practice, this would mean that all the major roads in Greater Cairo would be fully congested all day indicating volume/capacity (Vol/Cap) ratios greater than 1.0. Furthermore, In 2008/2009, the transport sector was responsible for 38% of the final energy consumption in Egypt and for about 25% of the energy related CO2 emissions and is the fastest growing source of CO2 emissions in the country. The total amount of greenhouse gas emissions from the transport sector in Egypt in 2008/2009 was estimated at 39 million tons of CO2.

No single solution can be expected to comprehensively address such concerns; instead, a more holistic approach is needed. Herein lays the need for sustainable-Technology enabled solutions for transport sector in Egypt. Sustainable development is widely viewed as development that improves the standard of living and quality of life, while at the same time protecting and enhancing the natural environment and honouring local culture and history. In this context, sustainable transportation is seen as transportation that meets individuals mobility needs while also preserving and enhancing human and ecosystem, health, economic progress, and social justice now and for the future.

Solving these problems by suppressing demand or expanding supply is not realistic as in either case there are constraints in place. It will become necessary to regulate the supply–demand interface by both adjusting supply-side control devices and encouraging reallocation of trips among modes, in time, and/or between facilities. The challenge is to find and implement solutions that achieve an efficient reallocation of network capacity over time and space without seriously violating any individual user’s preferences for mode, routing, departure, and/or arrival time. The redistribution of trips among available modes and across time tend to favor better pre-trip decision making while the redistribution of trips between facilities tends to be a real-time decision making problem. The rapid development of information and communication technology in the last few decades provides new opportunities to manage and perhaps alleviate such problems. Intelligent transport systems (ITS) in which knowledge of transport patterns, preferences of the transport users, the status of the transport infrastructure and other factors are brought together may help in better managing the factors that cause these problems.
The purpose of this paper is to describe the specifications of conceptual framework of an Internet based country wide transportation data centre for Egypt (EGY-ITRANS). The EGY-ITRANS centre is a Cooperative Multi-agent Transportation Management and Route Guidance System. The EGY-ITRANS system provides real time schedule, locations, arrival times, and routes to the travellers as well as commercial end users connected to the internet via 3G GSM network. The system covers core systems such as Vehicle Tracking System, Real Time Information System and Central Control Station. Core technologies include Geographical Positioning System (GPS/GSM), Electronic Display Systems, and Information & Communication Technologies. The development part of EGY-ITRANS has three key technical activities. First, development of smart traffic software platform through the use of mobile phones to collect real-time traffic data. The smart traffic software platform features framework for predicting and monitoring dynamic real time traffic flows using the cell phone data. Second, create a compact real time routing algorithms for capturing explicitly fuel consumption and emissions in a mixed-fleet vehicle routing program and analyse the opportunities for simultaneously reducing costs and negative environmental impacts. Third, development of traffic information engine for transformation of raw data into usable traffic information. The end user of the system will be offered with an easy to use graphical user interface for information analysis and administration tasks. The web based access and extensible mobile access to the proposed system will be designed to be intuitive for the end user to maximize the effectiveness and efficiency of the proposed system.

BACKGROUND

In the late 1980s, technological advances in the gathering and synthesizing of transportation data and the presentation of information to travellers started to trigger visions of increasing capabilities of travel information services, along with an increasingly important role for such services in traveller decision making [e.g.1-5]. These visions gradually led to the introduction of the acronym ATIS for Advanced Traveller Information Services [e.g. 6-8]. ATIS started out as systems that, based on observations of the current situation in the transport network in combination with historic data, provided car-drivers with travel time estimates, advice or route guidance, and transit-riders with up-to-date messages on delays of trains or buses. The information was provided to travellers through radio, variable message signs, telephone services and, starting in the mid-1990s, internet-sites.

In the academic research area, many researchers and organizations have conducted a substantial amount of research on ATIS. Chorus et al. [9] summarized research about the relationship between travellers’ choice behaviour and travel information. Their review demonstrates that the majority of this work is concerned with explorative empirical research or with the exploration of alternative theories to model such behaviour. More importantly for the present study, most of this research concerns public, descriptive information; considerably less is known about the next generation of travel information systems that will be based on personalized, dynamic descriptive and prescriptive information. Most research has looked at the correlation of information use [e.g.10, 11] and willingness to pay [e.g. 12]; less has been done on the development of theories and models to understand traveller responses.

In relation to public transport information systems, displays that provide real-time arrival information for buses, subways, light rail, and other transit vehicles are now available in a significant number of cities worldwide, at places such as rail stations, transit centres, and major bus stops. With the increased availability of powerful mobile devices and the public availability of transit schedule data in machine readable formats, a significant number of tools have been developed to make this information available on a variety of interfaces, including mobile devices. These systems are often cheaper to deploy than fixed real-time arrival displays at a large number of stops. Further, these systems, especially mobile devices, can support additional, personalized functionality, such as customized alerts. One of the first online bus tracking systems, BusView, was developed by Maclean et al. [13]. More recently, Google Transit, which was started as a Google Labs project in December 2005, is now directly integrated into the Google Maps product on many mobile phones and provides transit trip planning for more than 400 cities around the world [14] (although not real-time information). Interfaces to Google Transit exist on a variety of mobile devices, making use of location sensors such as GPS and WiFi localization on the device to determine a starting location for trip planning. While Google Transit has been useful to transit riders around the world, it is also significant for establishing a de facto standard for exchanging transit schedule data: the Google Transit Feed Specification (GTFS). Development ecosystems have grown out of the public availability of this data, with many so-called “transit-hackers” working on innovative uses of transit data. The Portland TriMet third-party applications page [15] lists over 20 applications using Portland’s transit data, many targeted at providing transit data on mobile devices and many of which use localization capabilities of these devices to return location relevant results.

All of these systems make use of existing traffic monitoring infrastructure. However, current systems only evaluate route by travel distance, travel time or travel cost. As in some cases these metrics are unable to give sufficient granularity to make informed choices regarding suitability. It is envisaged that the value of ATIS systems can be increased by the addition of additional parameters covering congestion, delay, parking availability at destination or at waypoints (specific to each travel mode), number of transfers, walking distance, weather. In particular it is felt that current systems are imprecise or unable to indicate the environmental impact of a trip. This may be evaluated by the amount type of air pollution produced on a trip. With more informed data made available through an ATIS system this has the potential to promote behaviour that is more environmental friendly.
EGY-ITRANS ARCHITECTURE

A representation for EGY-ITRANS system and its key components is shown in Fig. 1. The top portion of the figure depicts the supply-side management system hierarchy. This reflects a distributed, hierarchical system of virtual managers that work together in parallel to maintain quality of service across different sections of the roadway network. They are responsible for supply-side management functions such as collecting and storing data gathered from the network, adapting traffic signal and ramp meter timing plans, coordinating incident management, and disseminating traveller information through variable message signs and highway advisory radio. In a fully automated Advanced Transportation Management Systems, these managers are computers.

The lower half of the picture depicts the set of travellers and flow entities seeking to travel through the network. Users will be divided by mode as well as their telecommunication connectivity. As shown in this Fig. 1, a transportation network can accommodate a diversity of participants.

An information service provider (ISP) is shown on the left side of the figure. ISPs collect, process, store, and disseminate transportation information to the network users. An ISP provides a general data warehousing function, collecting information from transportation system operators, and redistributing this information to other system operators in the region and other ISPs. The second role of an ISP is focused on delivery of traveller information to subscribers and the public at large. Information provided includes basic advisories, real-time traffic condition and transit schedule information, yellow pages information, ride matching information, and parking information. ISPs can also provide the capability to provide specific directions to travellers by receiving origin and destination requests from travellers, generating route plans, and returning the calculated plans to the users. In practice, there could be one or more ISPs that serve a roadway network. The right side of the figure depicts information sources; a class of entities not directly tied to the supply managers or system users that are connected to the knowledge network to provide support information. Examples of information sources include weather stations and special event generators.

Fig. 2 illustrates an Integrated Transportation Management/Route Guidance fundamental subsystem of EGY-ITRANS. The subsystem consists of 3 main modules as shown in Fig. 2.

1. Automated vehicle location and tracking system using GPS/GSM technologies
2. Central expert system
3. Graphical User Interface (GUI) to provide services to end-users

AUTOMATED VEHICLE LOCATION AND TRACKING SYSTEM USING GPS/GSM TECHNOLOGIES

The aim of this module is to create a dynamic transport system and traffic flow maps by determine vehicles positions by cell phone applications, the cell phones get the position information using hybrid positioning and GPS capability, then the application send the position to a central expert system. The system automatically updates the database with latest position, speed and direction information of each vehicle. The server carries out information processing and analyzing in order to cater for different requirements of the users of our system.

CENTRAL EXPERT SYSTEM

The central expert system is structured in a multi-agent way and inspired by a learning-based approach. The multi-agent framework is consisted of eight agents that can be classified into two categories: Active Agents including a GIS-agent, a simulation-agent, a routing-agent, a passenger preference-agent, and a forecasting-agent; and Assistant Agents including a feeder-agent, a loader-agent and a feedback-agent.

Due to the complicated topology of the transport and road networks, the GIS-agent appears necessary. Complicated structures, such as one stop serving multiple lines and asymmetry in minimal-time paths between the same OD pair, are easily handled using powerful capabilities currently available within GIS packages.
The simulation-agent is essential to the framework. The simulation-agent consists of two sub-agents as follows; a transport system microsimulation-subagent and integrated simulation model with traffic mobility and wireless communication subagent. The transport system microsimulation-subagent is developed to represent the dynamics of the public transport system at the network level with a detailed representation of branch/vehicle-level operations. The microsimulation model represents the movement of each vehicle between stops as a function of the link speed, with explicit representation of the general traffic. Meanwhile, it microscopically represents individual passenger alighting and boarding activities at each stop, including the interactions among passenger agents and between passenger agents and the transport network. The supply model acknowledges loading priorities at stops and represents congestion through fail-to-board handling. This is modelled as a “discrete-time, event-driven” simulation model, where the simulation model clock advances every time step (e.g. second) and handles events as they occur at varying increments. The integrated simulation model with traffic mobility and wireless communication subagent implements the feedback of disseminated traffic information on the user behaviour. Therefore this agent predicts near time changes in the traffic volume. This increases the knowledgebase the forecasting-agent can access. The exactness and forecasting reliability is increased. Another result provided by this agent is the relation between the penetration rate of traffic participants connected to the information system and the uncertainty of forecast results. Then the provided simulation results can help to develop cost effective and realizable application scenarios.

Regarding the routing-agent, there are two main characteristics of this component: the first one is supporting multimodal travel where various combinations of modes could be taken into account; another is supporting the use of real-time information that is received from the GSM network. The main functions of the routing component can be classified into route planning and navigation, where the former is considered as static and the latter is considered as dynamic. The route planning part can be further categorized into full-information routing and partial-information routing. In full-information planning, the user gives definite specifications of origin and destination, whereas in partial-information planning, the user may tell the system by natural language where he or she wants to go or what he she wants to do. In the navigation part, the system shows the real-time position of the user based on GIS and provides directions for further steps. Whenever schedule conflicts or opportunities arise or are to be expected, the system gives alerts and guidance on that level.

Representing passengers as agents is critical to account for the differences not only in passengers’ preferences but also passengers’ learning and adaptation mechanisms. The preferences are incorporated in generalised link costs functions for transport networks so that a standard least-costs algorithm is applied to find an optimal path through the network. Since the network is generally represented as a super network of different modalities, link costs functions are also specified for transfer links. The generalized cost functions are dynamic and is updated each time a change in the state of the traveller causes a change in his/her preferences for travel option. The cost functions will be personalised based on the system’s estimates (beliefs) of personal preferences. Dynamic information such as waiting times, effort and inconvenience involved in transfers can be represented in the generalised cost functions associated with transfer links and, hence, can be taken into account when searching for an optimal path for a multimodal trip.

The learning-based approach works as follows. For a given day, the feeder-agent is responsible for handling the input process. The input to the framework can be through user interface, or the framework can be integrated with a larger trip-based (or emerging agent-based activity-based) urban transportation model. For each passenger-agent, the GIS-agent provides the feeder-agent with the catchment area (available/accessible transport modes) and expected walking access/egress times to/from origin/destination public transport stops. The outcome of this interaction is a set of possible combinations of departure time and path choices for each passenger-agent – i.e. action space. Each passenger-agent has a planner component that is responsible for selecting only one combination that reflects that passenger-agent’s preferences and is based on the mental model of previous experiences. This results in a stochastic process of different choices for individual passengers; therefore the loader-agent’s task is to provide dynamically passenger-agents’ choices to the simulation-agent. Then, the simulation-agent handles the dynamics of the transportation network according to passengers’ choices and provides experienced measurements for individual passengers. Afterwards, the feedback-agent is responsible for updating each passenger-agent’s memory, according to every passenger’s learning mechanism. The whole process repeats for many days.

GRAPHICAL USER INTERFACE (GUI) TO PROVIDE SERVICES TO END-USERS

The end user of proposed system will be offered with an easy to use graphical user interface for information analysis and administration tasks. The web based access and extensible mobile access to the proposed system will be designed to be intuitive for the end user to maximize the effectiveness and efficiency of the proposed system. We will incorporate GIS techniques to provide location specific data organized in layers so the end user can better apprehend the information provided by the system.

CONCLUSION

This paper presented a conceptual model for EGY-ITRANS system and its key components. In this contribution, we presented the innovative basis of EGY-ITRANS that use mobile network data, which are taken anonymously from the cellular network and processed into traffic information for the transportation authority.

The EGY-ITRANS centre is a Cooperative Multi-agent Transportation Management and Route Guidance System. The EGY-ITRANS provides real time schedule, locations, arrival times, and routes to the travellers as well as commercial end users connected to the internet via 3G GSM network. The system covers core systems such as Vehicle Tracking System,
Real Time Information System and Central Control Station. Core technologies include Geographical Positioning System (GPS/GSM), Electronic Display Systems, and Information & Communication Technologies. The development part of EGY-ITRANS has three key technical activities. First, development of smart traffic software platform through the use of mobile phones to collect real-time traffic data. The smart traffic software platform features framework for predicting and monitoring dynamic real time traffic flows using the cell phone data. Second, create a compact real time routing algorithms for capturing explicitly fuel consumption and emissions in a mixed-fleet vehicle routing program and analyze the opportunities for simultaneously reducing costs and negative environmental impacts. Third, development of traffic information engine for transformation of raw data into usable traffic information. The end user of the system will be offered with an easy to use graphical user interface for information analysis and administration tasks. The web based access and extensible mobile access to the proposed system will be designed to be intuitive for the end user to maximize the effectiveness and efficiency of the proposed system.

REFERENCES

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There is a recent realization by major cities of the MENA region that sustainable growth is contingent upon a significant shift from the near-complete-reliance on the automobile and informal public transport, to the provision of a modern organized multi-modal public transport system. The targeted multi-modal transport system should be characterized by giving larger roles to two of its components: walking/cycling and organized modern high capacity modes. It is so because many of the MENA region cities, and in the absence of organized public transport, had to rely on private automobile, taxi, and in some cases also on various types of informal public transport, mostly operating badly maintained vehicles, either in the form of shared taxi or micro-buses.

Taking the path for making cities walkable and also providing high capacity modern public transport faces many challenges. Notwithstanding the barriers related to the huge financing requirements of high capacity modern public transport, faced by many of the region’s cities, there are still barriers unrelated to availability of funds. This paper covers some of those other barriers. One must keep in mind that while this paper makes some generalizations for the purpose clarifying the issues being discussed, the wide divergence among the characteristics of MENA cities renders specific issues not necessarily applicable equally all across the region.

**BACKGROUND**

Many cities of the MENA region have undergone phenomenal population growth during the last several decades. This population increase was, in addition to normal demographic growth, mostly due to urbanization (movements of nationals from rural areas to urban areas), to large population displacements as a result of conflicts in the region, to the sizable reliance on foreign employment to support the requirements of economic growth, or even a combination of all of the above. The fast growth of MENA cities, especially in the GCC countries started in the second half of the 20th century triggered by the economic boom as a result of the discovery of oil. Similar fast growth was in cases forced, for example on Amman, as a consequence of the conflicts in the region (1948, 1967, and 1993).

The combination of vast increase in city population that accompanied the concurrent fast economic growth (mostly in oil exporting countries of the MENA region) have resulted in an urban growth at a fast pace that made careful planning for it a difficult challenge to meet.

In comparison, old cities in many other regions of the world have reached their high level of mature development by the late 19th century, before the age of the automobile. Those large cities in Europe and the USA had met their urban transport demand by developing rail transport networks, mostly in the form of trams (street-cars), subways (metros), and commuter rail. Those public transport modes shaped the form of those cities.

With the advent of the car, especially during the post WW II era, cities mostly in the USA but also in Europe and the rest of the world have witnessed a strong suburbanization accompanied by a sizable sprawl. An entire way of life started to develop in a manner which favored car users. The advantages presented by the private auto in giving door-to-door service, flexibility and availability helped it gain popularity. The near predominance of the car due to its intrinsic characteristics was also accompanied by the initiatives of...
the car industry in the USA of marginalizing the role of public transport by buying-out rail right-of-way and supporting the onslaught of the taxi that eventually pushed the street-car out of American cities. With that evolved a new life style centered on the car: low density suburban living in single family dwellings, drive-in restaurants and movies, and eventually the shopping mall surrounded by vast areas of free parking.

Concurrently, the US started constructing its National System of Interstate and Defense Highways (commonly known the Interstate). A system of fully controlled-access highways, with high design speed and geometric standards as to lane widths and vertical clearances. Sections of the Interstate highways penetrated the urban fabric, cutting through neighborhoods and rendering pedestrian movement impossible. All that rendered the city center a ghost town after dark and left it to suffer urban blight.

The beginnings of the reversal of this trend in the USA did not start till the 3rd quarter of the 20th century, in response to growing concerns regarding the air pollution caused by the excessive reliance on the private car, is a testimony to the unsustainability of car-oriented urban areas. Currently, the USA is in the forefront of advocacy of Transit Oriented Development (TOD).

One might wonder why a discussion of what has happened in the USA is relevant to the objectives of this paper. It is relevant because in the MENA region the USA was the role model to follow. The American approach was being replicated by foreign consultants and by engineers who were trained in the USA. The adoption of US design standards was not matched by a similar replication of the other US regulating mechanisms and controls, including but not limited to a strict enforcement of traffic ordinances, land use licensing, and a sophisticated taxation system which does not only target increasing public revenues, but also and more importantly influencing consumption behavior.

**DIAGNOSIS**

Fast growing cities in the MENA region, especially those that have been enjoying prosperity, tended to seek solutions based on increasing the supply of transport to match the demand for it. And in-line with the good practice of anticipating growth, many cities oversized and overbuilt their transport networks. This provided an excellent opportunity for real-estate developers to seek for their projects cheaper land further out; and thus encouraged urban sprawl. Attempts of many cities to curtail this trend, because of the heavy and expensive burden it puts on the municipal authorities to provide the needed utilities and services, were rarely successful. This phenomenon is visible in the abundance of vacant property/un-built lots within the cities. Few cities in the MENA region and only recently, started to impose taxes on unbuilt property to fight against hoarding land for speculation.

This pattern of development entered many MENA cities into a vicious circle. The vicious circle that starts by developing land uses built for the car user, which will result in traffic growth and eventual congestion, which encourages further low density development away from the congested city center. Relieving congestion in the city center was attempted through building multi-lane urban expressways. And as congestion is most critical at intersections, traffic volumes will eventually reach a level not possible to regulate by roundabouts and traffic signals, thus the need for grade separation arises. Grade separations, and especially under passes built for high design speeds and generous vertical clearance tend to be long, making walking across difficult and dangerous, and diminishes the ability of pedestrians to reach public transport, thus resulting in even further reliance on the car. In some situations, taking a taxi to cross from one side of the street to the other becomes the only safe option.

Unfortunately there was not an early recognition of the unsustainability of this urban development form. The development of cities along the patterns that prevailed in many American cities in the middle of the second millennium was still copied as best practice. Divided thoroughfares with wide lane widths and other expressway design standards were being built in urban areas, and in many cases little attention was given to the needs of pedestrians, such as obstacle-free sidewalks and safe street crossings. And since construction of buildings was at an accelerated rhythm, in most cases building permits were given before the vertical alignment and cross-sections of the abutting thoroughfare was decided. That resulted in levels of buildings’ entrances mismatched with the level of the sidewalk. Accordingly, the sidewalk becomes pedestrian unfriendly due to the multitude of obstructions and frequent changes in sidewalk levels.

Major thoroughfares became lined up with commercial areas that thrived on business from car drivers, who park their vehicles illegally while making a purchase. The American drive-in culture was copied, but without the required off-street parking that accompanies it.

Along new thoroughfares, there is no control over spacing of curb cuts. Curb cuts tend to become closely spaced and interrupt safe pedestrian movement. Curbed sidewalks, even those equipped with un-mountable curbs, become occupied by vehicles, with the proliferation of SUVs and lack of enforcement. Vehicles parking along street corners and occupying pedestrian crossings further hinder pedestrian movement. All this is prohibited by prevailing traffic ordinances, but is rarely uniformly enforced.

This vicious circle is one of the most challenging barriers to the introduction of organized high level-of-service public transport essential for achieving sustainable growth.

To summarize, apart from the scarcity of funding, the so-called social barriers, unfavorable climatic factors, and the shortage in the qualified national human capital, barriers to the success of public transport are mostly a result of the prevailing urban planning and design practices in many MENA cities, which include:

- Lack of coordinated policies required to achieve sustainable development
- Low-density development which reduces the number of trip ends within a walking distance from a public transport stop, thus reducing potential ridership and financial viability
- Urban streets designed without due attention to the needs of the pedestrian and non-motorized transport
- Underdevelopment of the regulatory function
- Less than adequate enforcement of regulations
**RESPONSE STRATEGIES**

There are a multitude of coordinated strategies that have to be adopted to mitigate barriers to sustainable public transport in fast growing cities of the MENA Region. This paper concentrates only on a limited spectrum of these barriers facing introducing modern and sustainable public transport in the cities of the region. Barriers related to financial, institutional, and social sustainability are outside the scope of this paper. This paper addresses solely the urban form and related barriers.

Regarding urban form the following is recommended:

- **Adopt an urban development form favorable to public transport**, according to the following principles:
  - Densification of land development especially in the vicinity of public transport lines and stations.
  - Resort to attached structures in order to shorten walking distances to several public transport stations.
  - Design for mixed land use neighborhoods
  - Provide a dense well-connected network of streets and pathways to minimize the distances walked
  - Give priority to none mechanized transport modes to encourage their use

- **Develop a regulatory framework that supports the desired urban form**, such as:
  - Taxing vacant unbuilt urban property to curtail speculative behavior
  - Allowing a higher floor area ratio (FAR) along high capacity public transport corridors
  - Adopting parking policies that target the rationing of the supply of parking, to discourage reaching specific areas by car
  - Adopting a parking policy that treats on-street parking as a privilege and not a right, and be only provided for a fee in business areas, to further discourage car use
  - Revising building codes as to parking spaces required per unit floor area, by specifying a maximum rather than a minimum for that, in specific areas

- **Revise urban design standards in favor of pedestrians**, such as:
  - Lane widths to be modest in order to calm traffic and shorten pedestrian crossings
  - Avoid as much as possible vehicular grade separations, especially if they interfere with pedestrian flows

- **Consider reduced vertical clearance underpasses that serve light-vehicles-only, at specific locations, as they require shorter vehicular ascents and descents**
- **Avoid as much as possible multilane one way thoroughfares that encourage vehicular speed, more difficult to cross by pedestrians, and make it more difficult for bus users to know where from to take the bus on the return trip**
- **Provide for obstacle free sidewalks with good lighting and shading**
- **Reduce curb cuts and vehicular access to buildings, especially where they interfere with pedestrian flow**
- **Intensify enforcement and outreach in order to achieve the desirable reforms**
  - Consistent, continuous, and uniformly applied enforcement of all laws and regulations, especially violations related to parking and those endangering pedestrians
  - Education and outreach are central to public transport advocacy. This effort should be addressed to all, from the top of the authority pyramid down. Special efforts are to be made to correct misconceptions held by decision makers, and to bring up new generations with appreciation of the importance of sustainability

- **Adopt positive and negative incentives to encourage public transport oriented development**
  - Utilize taxation and tax exemptions as instruments to rationalize consumption and enhance sustainable urban growth
  - Develop and enforce regulations regarding the commercial use of the built property at the street level, to eliminate “drive in” activities in the public domain

The reforms and actions proposed in this paper require dedicated efforts that do not bear fruit overnight. They involve adopting integrated policies that require political commitment and backing to be realized, and skillful and sustained efforts to be implemented. Putting fast city growth on track and mitigating current shortcomings are essential for achieving sustainable development. Some fast growing cities in the MENA region have realized that quite early and worked for sustainability. The example of Dubai should be a source of inspiration for other fast growing cities of the MENA region.
INFORMAL TRANSPORT IN MENA, WE DON’T KNOW ENOUGH

By Amr Ramadan - Senior Research and Transport Officer - UITP MENA CTE - Dubai

SHORT BIOGRAPHY

Amr Ramadan is the Research and Partnerships Officer at UITP MENA Center for Transport Excellence where he is currently conducting research on administrative and regulatory reforms in public transport and informal public transport in the MENA region. Ramadan has 10 years of diverse policy research experience.

Not much is known about the informal transport sector in the MENA region, the figures and data available about the size and importance of the sector are limited and outdated. It is surprising that there are only a handful of academic papers and articles on this important and crucial mode of transport. What we do know is that this sector transports a large part of the populations in major MENA cities and that they compete with planned, private and government run, transport operations. They also make it hard for governments to properly plan and develop public transport projects and networks. This article aims to use research and examples from the significant international experience to better explain informal transport in the region, its importance and how it can be integrated into efficient and sustainable urban mobility plans for the region’s cities.

1. DEFINING AND CATEGORIZING INFORMAL TRANSPORT IN MENA

The informal transport sector in the MENA region comprises privately operated, small-scale services which are also sometimes referred to as “paratransit”, “artisanal transport”, “low-cost transport”, “intermediate technologies”, and “third-world transport”.

Informal transport operations usually involve an owner, a driver and a controller which could be local government, private company or operator associations. Typically, the driver would have the operational responsibility and commonly pays the owner, usually daily, who pays the controller (licensing/registration fees) and the driver keeps the surplus as his revenue. This is the scheme observed in many MENA cities.

Informal transport is usually prevalent where there is a lack of fiscal and institutional capacity in a city which leads to the deterioration of formal public transport and formal transport services fail to meet transport demand. Small-scale informal operators, legally or illegally, enter the market to fill these gaps, complementing or competing with regular transit services, entering neighborhoods poorly served by formal operators and responding promptly to shifting market demands.

These modes of transport may be considered informal for different reasons and can be classified into 2 different categories:

1. Lack of official and proper credentials or the necessary permits or registration (totally illegal)
2. Licensed and legal, with necessary permits or registration but:
   a. Are subject to minimal enforcement
   b. Fail to meet certification requirements for commercial, common-carrier vehicles – such as minimum vehicle size, maximum age, or maintenance standards
   c. Licensed to operate on a particular route but operate in unorganized manner outside government plans or routes and have flexible routes, timetables, and/or fares

Cervero (2000) outlines the differences between formal and informal sectors in Tables 1 and in Table 2 summarizes the different classes of paratransit services which can be found in the MENA region:
In many developing cities in the MENA region, informal transport has become an important component of overall transport services. Over the last decade, in Algiers, Cairo, Alexandria and Casablanca, and possibly many other MENA cities (no data available), informal transport has become perhaps even the most common and widely used form of urban transport. The emergence of informal transport is mainly explained by the lack of public transport supply and the rapid increase in transport demand in urban areas.

Due to their overwhelming contribution to daily trips in MENA cities, see table 2. The dominance of these modes presents a challenge to both public and private transport operators but also perform a vital service for the low-income classes.

<table>
<thead>
<tr>
<th>MENA REGION</th>
<th>MODAL SHARE OF INFORMAL TRANSPORT</th>
<th>YEAR</th>
<th>SOURCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAIRO</td>
<td>52</td>
<td>2010</td>
<td>MOT, 2010</td>
</tr>
<tr>
<td>ALEXANDRIA</td>
<td>59</td>
<td>2014</td>
<td>CODATU 2015</td>
</tr>
<tr>
<td>ALGIERS</td>
<td>94</td>
<td>2004</td>
<td>Godard 2006</td>
</tr>
<tr>
<td>CASABLANCA</td>
<td>44</td>
<td>2008</td>
<td>CODATU 2015</td>
</tr>
</tbody>
</table>

Size of informal sector in MENA Cities

However, the disorganized and aggressively competitive nature of these modes may jeopardise the development of new transport modes such as light rail and BRT projects. Based on the international experience, new developments or policies that effect informal transport either through stricter regulations, or competition from subsidized more effective modes, may lead to protests, strikes and even violent actions from the operators when governments intervene. This puts the success of proposed or transport projects reforms at risk.
It is therefore crucial to take informal transport into account for the development of efficient urban transport system in the MENA region. This means that appropriate strategies should be made to enable a smart integration of informal transport into public transport system. The building of integrated strategies necessitates a deep understanding of the current situation and of the dynamic of informal transport. However, there is a significant gap in knowledge and research on informal transport in the MENA region.

Outdated information on informal transport is available for only some of these cities and further research is currently being conducted at the UITP MENA Center for Transport Excellence in Dubai.

2. STAKEHOLDERS OF INFORMAL TRANSPORT

Users – mostly poor- middle class- live/ work in informal areas without access to formal transport

Informal operators – private freelancers -sometimes own vehicles

Informal transport operator’s factsheet

- They play an essential role in supporting the livelihood of other urban working poor, providing cheap and flexible transport to and from their workplace, markets, customers, etc.
- They lack representation are unorganized or in effectively organized
- They endure job insecurity, harassment and corruption, poor (and often dangerous) working conditions, and no access to training.
- The owners of informal transport are usually: i) retirees, ii) people with low-incomes, and iii) civil servants (Cervero,2000)

Formal operators

- competitors (compete with informal operators over main routes)
- managers (may be asked to manage informal operations and include them as feeder operators

Policy makers – government planners, urban designers, transport authorities, local municipalities, regulators, managers

3. WHY INTEGRATING INFORMAL TRANSPORT IS IMPORTANT FOR PUBLIC TRANSPORT AUTHORITIES

Summary

- Public transport authorities cannot ignore the size and importance of informal operations in some cities and their effects on public transport and city planning
- Public transport authorities should consider dealing with informal transport as an effort to reduce emissions, helping combat climate change
- Public transport authorities should consider dealing with informal transport as an effort at improving road safety, combating congestion increasing the quality of life in the city

Before Transport Authorities choose a strategy in dealing with informal transport, UITP believes that it is necessary first to understand what makes informal transport so successful as well as the challenges they present to governments and private operators. An overview of international case studies and examples show the causes, benefits and challenges posed by the sector.

What are the benefits for transport authorities and policy makers?

- Informal transport fills the gap left by insufficient public transport available in many MENA cities
- Informal transport decreases the load on existing formal operations
- The sector provides jobs for low-skilled in-migrants and poor as an entrepreneurial activity
- Informal transport is increasingly catering to the middle class
- Informal transport provides service coverage in areas devoid of formal transit
- Informal transport sometimes complement and act as feeder mechanisms to public transport

CHALLENGES FOR TRANSPORT AUTHORITIES AND POLICY MAKERS

From a safety/health perspective:

- Lack of accountability due to weak regulation and enforcement
- Without public oversight, operators’ associations respond primarily to the interests of their members rather than those of their passengers, self-regulation of competition is often enforced through violent means, not excluding the assassination of rivals and aggressive intimidation of passengers

“During the 1990s, more than 2000 people died [in South Africa] as a result of paratransit-related violence, according to official statistics. Unofficially, the toll is much higher. (Cervero and Gulub, 2007)”

- As a result of this competitive pressure, drivers often pay little regard to traffic conditions, safety or other vehicles in the competition for passengers. But also towards the quality (and thus safety) of their vehicles in which they do not invest due to this fierce competition
- They are gross polluters, and mostly the poor technical condition and aging vehicles with under-tuned engines, diesel and low-stroke engines, frequent acceleration and deceleration in congested traffic contributes significantly to air pollution and high-energy consumption

From a management and planning perspective:

- Unpredictable scheduling and service as they operate in an unorganized manner without a comprehensive view or plan
- Their capacity to carry passengers is considerably lower than those of the bigger buses or, in particular, light rail or BRT thereby contributing to congestion;
- They often disrupt traffic by stopping short or slowing at curbs to collect/drop passengers thus causing congestion for other road users;
- Fragmented ownership makes planning and management of the industry a difficult task

37
From a financial/business perspective:

- Some informal operators operate outside of the established regulatory framework and without proper vehicle or driver licensing leading to labor abuses, evasion of taxes and fees.
- They compete with formal public and private operators; they often run parallel to formal buses and other public modes, thus taking away passengers from the formal public/private operator, and affect their profit margins, not allowing for investment in better quality modes or integration with formal modes; although some modal integration does exist at some metro and bus stops in some cities.

By operating in such a manner, informal operators may undermine efforts to develop more integrated and sustainable public transport systems such as the implementation of new transport schemes (Bus systems, BRT, LRT) particularly on main routes and corridors which are currently heavily served by informal operators.

Codatu outlines the challenges faced by governments in figure 1.

4. WHY IS INTEGRATING INFORMAL TRANSPORT IMPORTANT FOR PUBLIC/PRIVATE OPERATORS?

- Operators need more intelligence on how to compete with them or how to best integrate them for most beneficial results.
- Informal transport is now able to compete because:
  - They provide affordable forms of transport for lower and middle income workers, university students and other users with no access to public transport.
  - Some offer guaranteed seats which may make it more attractive than formal buses.
  - In congested cities, informal transport, being smaller, can manoeuvre more easily in the traffic flow getting users to their destination faster than larger buses, so they are more competitive in cities with large informal unplanned areas.
  - Accessible within a short walking distance of areas of interest in cities; more accessible than some formal services; almost door to door.
  - During night shifts, when buses are no longer running, they sometimes are the only means of getting around.
  - Their entrepreneurial free market nature allows them to respond swiftly to transport demand and innovate. Open competition makes them very competitive and they can even be more competitive than formal modes.
  - Informal transport sector prices are based on open market and thus are sometimes more agreeable to customers. Operators receive no subsidies or capital assistance. Unencumbered by rules and bureaucracy, independent operators are ultra-responsive to emerging and shifting market trends.
  - By organizing into route associations and cooperatives, research shows that they can lower per-seat costs to the point of being competitive with larger companies.

5. FRAMEWORK FOR DEALING WITH INFORMAL TRANSPORT

Based on an analysis of the international experience in dealing with informal transport in Asia, Latin America and Africa, we have categorized 3 main types of policy options when deciding on how to deal with informal operators: Management and organizational policies, regulatory policies and engagement policies.

**MANAGEMENT AND ORGANIZATIONAL POLICIES**

These policies address the decision of how the operators will be formalized and in what structure they will fit once they are formalized:

- In case of allowing informal operators to compete with formal modes, authorities could organize informal operators into cooperatives, which establish a democratic governance structure to manage operators on certain routes with oversight by local government. These coops will be held responsible for planning, safety, emissions and standards by the overseeing government entity.
- In case of integration and formalization of the informal modes, authorities could consider forming private or public companies to manage operators on certain routes with public oversight.
CAPE TOWN AND MYCITI PROGRAM - THE PRIVATE OPERATOR OPTION

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- Road-based operators licensed on routes affected by the new BRT projects were to be given the opportunity to become the operators of the new services, and would be contracted to operate these services over a number of years.
- Informal transport operators had a strong position in terms of negotiations because they had existing licenses. Eventually, existing operators would have to withdraw their existing services, the operating permissions for these services would be cancelled, and the paratransit vehicle would be surrendered to the municipality to be scrapped and the operator would then be allowed to operate the new BRT buses.
- The first round of operating contracts would be negotiated with the existing formal/informal operators, giving them the upper hand, while in the later phases of the program operations would be put out to tender.
- Until the eventual completion of the reform program, informal transport not yet included in the program, formal buses and BRT would operate side-by-side.

CASE STUDIES FOR MANAGEMENT OPTIONS FOR INFORMAL TRANSPORT

SANTACO, SOUTH AFRICA - THE COOP OPTION

To deal with the problem of the fragmented ownership structure and chaos in the informal transport sector in South Africa, in 2001, the national government supported the creation of a hierarchical representative structure within the informal transport sector, the South African National Taxi Council (SANTACO). This was to make it easier for engagement and negotiation between government and informal transport operators at a national level. The government required the council to support operator associations’ applications, thus beginning the formalization process.

Also, in the case of Boagata, a large number of informal bus owners made it difficult for the government to negotiate with them. As a result, some bus owners created Associations of Small Bus Owners, Apetrans, to help them gain leverage in policymaking.

MANAGEMENT AND ORGANIZATIONAL STRUCTURE OF TRANSMILENIO BRT PROJECT, BOGATA - THE PUBLIC/PRIVATE OPERATOR OPTION

- "Besides seeking to improve public transport services for passengers, the introduction of Transmilenio is, at the strategic level, an attempt by the city government to formalize public transport from the paratransit sphere to counteract the destructive competition between associations and individual operators."
- "TransMilenio S.A. is a public company owned by the city government. Its responsibilities are, to plan and ensure service delivery, to control compliance of operators’ performance with the contract, to manage the system’s maintenance, and to plan improvements and expansions."
- TransMilenio is not responsible for the actual provision of bus services; they are merely intermediaries between the bus owners and the government.
- Formal and informal bus companies were allowed to operate on Transmilenio routes by forming larger bus operator companies, who would operate BRT and feeder buses.
- For informal bus owners, the main incentive for them to join these companies was to have access to routes that have a high volume of passengers and a high turnover which meant more revenue for them.
- Given these institutional arrangements, the informal bus drivers become critical actors in the provision of public transportation services in Bogota. The structure of Transmilenio S.A is shown here in figure 1.

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REGULATORY POLICIES

These involve the issuance and enforcement of rules and standards to make sure informal operators’ vehicles act as complementary carriers or feeder systems in some cases, or if they are allowed to directly compete with formal bus and train services, that they must do so fairly and within the rules of law.

Regulations for informal transport include:

• Allowable vehicle specifications and labor practices of private companies/coops on the route
• Incentives for operators to join formal operations
• Vehicle scrapping schemes where old run down vehicles are bought by the government and scrapped and give owners a cash options or a share in new formal transport companies
• Infrastructural support as in building of terminals and stops and the rules which govern curbside behavior
• Managing licensing and fines
• Route management and enforcement of adherence to routes
• Enforcement of regulations and standards by local authorities

Enforcement is the key to organizing informal transport

“Effectiveness at curbing illegal and injurious urban transport services ultimately rests with a vigorous and dedicated program to enforce rules and requirements. This means devoting sufficient resources – trained officers, judiciary systems, administrators, technologies – to monitor activities in the field. It also means having the resources and legal bases to impose sanctions for violations, be they someone’s invasion of another person’s route, operating unsafe vehicles, under−insurance, or unruly driving behavior. Few developing countries, and especially the poorest ones, have the resources to achieve these enforcement ideals. In truth, urban transport tends to be way down the social−policy priority list.”10

Table 3.1. Pros and Cons Associated with Regulation of the Informal Transport Sector

<table>
<thead>
<tr>
<th>PROS</th>
<th>CONS</th>
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<tr>
<td>Protects public safety and welfare</td>
<td>Suppresses competition</td>
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<tr>
<td>Reduces over−competition</td>
<td>Adds administrative and overhead costs</td>
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<tr>
<td>Promotes fair pricing</td>
<td>Persupposes institutional capacity</td>
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<tr>
<td>Sets minimal service, fitness, and indemnity standards</td>
<td>Poses potential cognitive barriers undereeducated driver</td>
</tr>
<tr>
<td>Protects operators’ rights and interests</td>
<td>Invites abuse among underpaid en forcementofficers and civil servants</td>
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6. ENGAGEMENT POLICIES

These involve how stakeholders are engaged in the planning and implementation phases of new regulations on a specific route. This also includes decisions on when and with whom information on the plans will be shared, how participatory the process is and ultimately whether informal operators or informal transport users would be involved in the planning process.

Table 3.1. Pros and Cons Associated with Regulation of the Informal Transport Sector

Transparency during the launch of the first TransMilenio bus route

Planners, stakeholders, politicians and consultants were involved in choosing the location of the stations along the bus ways and the design of the feeder routes. At these meetings planners received feedback from the community including informal operators. All in all, TransMilenio planners held more than 300 meetings with the community.11 The informal operators fully understood the advantages and incentives to join the new projects.

6. GENERAL RECOMMENDATIONS FOR DEALING WITH INFORMAL TRANSPORT

They key to addressing the informal transport sector is to convince existing informal operators of the potential incentives and benefits of formalization so they can complement rather than compete with new PT schemes in cities. Engagement and marketing of reform, particularly the benefits to informal operators and previous users of this mode, is a crucial step in the formalization process.

- The time element is a key factor in the success of proposed reforms. Gradual changes in regulations and management structures can give informal operators time to adapt to the new system, sometimes this needs months or even years. As seen above, immediate and sweeping reform may increase the risk opposition and failure but may still be possible if the right level of planning, transparency and integration are there. Codatu have summarized different reforms and how fast or gradual they were implemented in figure 2.

- Informal transport could be regulated in the way described above with set rules and quality standards that insure they operate in a planned and efficient way that maintains all the advantages of this mode in terms of demand responsiveness and accessibility

- International experience shows that setting up new management structures is more successful on routes where there is already a planned change, for example routes with plans for Light Rail or BRT. This makes it easier to garner political and popular support for these reforms and gives operators the option of moving to other routes

- Due to their many benefits, a strict ban on informal operators may not be in the best interest of the public, international experience tells us that prohibition could lead to significant political and popular backlash due to high dependence on these modes and none of the previous attempts at prohibition have been successful

- While total acceptance (do nothing scenario) the significant problems caused by informal transport would continue and increase, putting public transport projects at risk and maintaining low safety and high pollution levels
• Also as discussed in the previous section strong enforcement and administration is key to achieving proper integration or competition.
• Finally, recent innovations in areas such as geolocation, data processing, and communication between objects, as well as the advent of the new shared economy, have enabled many new applications in the mobility field. Ride sharing and Taxi hailing apps, like the global powerhouse UBER, could be the key to unlocking the informal sector’s potential.

Figure 2: Transforming paratransit services using BRT-type systems

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1. Robert Cervero, Informal Transport in the Developing World, UN Habitat, 2000
2. Ibid
5. Ibid
7. Schalekamp, H., & Behrens, R. Engaging paratransit on public transport reform initiatives in South Africa: A critique of policy and an investigation of appropriate engagement approaches, 2010
10. Schalekamp, H., & Behrens, R. Engaging paratransit on public transport reform initiatives in South Africa: A critique of policy and an investigation of appropriate engagement approaches, 2010
12. Ibid
What is Big Data Analytics - an approach to examining large amounts of data to search for and uncover, hidden patterns, correlations, and other insights. With today’s technology and the large interconnectivity of passenger movements and interactions, it is possible to analyse the data and get answers from it almost immediately. Historically, these efforts have proven to be slower and less efficient than with a more traditional approach. The concept has been around for sometime, with most organisations aware that if they can capture all the data that streams into and out of their businesses, they can use analytics to derive significant value from it. Even decades ago before “big data” was understood, organisations used essentially basic analytics – manually manipulated spreadsheets – to uncover insights and trends.

The new opportunities driven by the speed and efficiency that big data brings provide significant benefit. Previous approaches would have been to reach out and collect large amounts of information, sift through and run analytical tools and techniques, thereby identifying and clarifying information that could be used for future decisions. Now, with all the systems available and under development, if managed correctly, it is possible to provide the businesses with immediate insight, develop quick responses and thereby stay agile in decision-making. This leads to an increased competitive edge not available in the past.

Consider a business like transport that relies on quick, agile decisions on a day-to-day basis to keep customers happy. Customer satisfaction can be hard to gauge. This is especially challenging in a timely manner to collect the data, then apply analytics to resolve potential problems before those issues become serious to the customers, or even worse, too late to fix.

The key consideration is to not let the size of the data; the speed of collection and the complexity distract you. You need to focus on the potential and actual use of the data to solve specific business problems and provide opportunities. To obtain the optimum return on investment, keep the end result in mind. What specific problem or difficulty are you trying to resolve or overcome? This changes the approach from a technological problem to a business enhancing solution.
PROJECT OBJECTIVES

We launched a pilot programme in 2015 with CASATRAM (Casablanca tramway operator) and its shareholder RATP Dev, and aimed to validate if the Big Data potential can be made relevant for our public transport activities. We also wanted to show how to take advantages of an installed modern ITS system (ticketing, operations) to improve our knowledge and transport services performance for the users, for us the operator, and the local PTA.

PROJECT IMPLEMENTATION

As a transport operator CASATRAM operates IT Systems (ticketing, SAE, CMMS, etc.) that were provided by CASA TRANSPORT, the local PTA. These provide the local tramway system with a wealth of data. We collect ticket “validations” through check-in and checkout machines on the stations platforms. This provides information on the changes in mobility behaviour caused by, disturbed operation conditions, Ramadan, special events, rain or overly hot weather, etc. Unfortunately, it is quite common not to use and analyse this huge amount of data because of regular operational and planning activities.

With this project we took the opportunity of a contractual mandatory Origin/Destination survey to explore the potential of a Big Data approach. We gathered validations, sales and operational data during a 3-year period from the commencement date to mid 2015, in order to select the most relevant periods for such an O/D survey. This methodology allowed us to really improve the accessibility of the results. Thanks to a dynamic interactive interface based on Datavisualization, the O/D results are easy to read, share, and understand compared to the usual “matrix O/D sheets”.

The combination of validation and operational data clearly showed the “danger zones” of overcrowding focused on differing periods and places. This study case is also fruitful to identify the key points which need to be tackled to address a big data approach and the paper will pinpoint them as “lessons learnt”.

For example, the analysis provided us with more than 300,000 lines daily, more than 100 million lines per year to enrich the Casablanca Data Bases just from the ticketing data! The problem of organizing and consolidating the data and its staging is then the key.

PROJECT RESULTS

The main results and benefits of this Big Data/Dataviz approach are the following:

Origins/destinations surveys - These types of survey are very common to help transport planning. Using the collected data, it was possible to derive an exhaustive sample of data (vs. very small sample in usual O/D methodologies) without any additional cost. It was a clear demonstration that using check-in data which are collected when every passenger in getting on board or accessing to a platform is a robust methodology to feed into the Origins/ Destinations matrix.

Below is the usual visualization of an O/D matrix. Not very pretty! Any analyst who has to use them for the design and optimization of lines and routes will have to mix several of these matrices in order to have an overall picture.

Figure 1: Shows the usual O/D matrix gathering all O/D links for a specific day.
The main advantage of using the “big data” is to manage long historical series of data to complete the coverage of some unmatched validations or missing periods. This allows the team to generate O/D Matrix even when the data are not available or only captured at the arrival or origin of the trip.

Another key point of such an approach is to dramatically improve the access to data and to transform “information” into being able to support a “decision”. Thanks to data visualization tools (AKA “dataviz”), all the information is transformed in a dynamic, easily accessible, flexible and easily probed picture. Every parameter may be changed into being able support a focus on a topic, a place, and a date/period that need to be assessed.

The results of new parameters can be derived within a couple of seconds thanks to the “cloud web based” solution.

Project Objective for the big data/dataviz approach is very simple: how can we change the timetable to move these stations from “red and orange” to “green”.

We tested several different scenarios with one constraint: do not add any tram/kilometre to avoid any additional costs.

The best scenario was to shift the morning hour when headways were moving from 5 minutes to 4 minutes (1 hour later). This

Using as a reference the objectives and expectations of our client the Casablanca Casa Transport regulator, we selected 5 different periods for the O/D analysis to stay as close as possible to the reality of Operations:
- Regular week day
- Regular week end day
- Summer Sunday
- Ramadan period

We developed an interactive tool to provide an easy access and flexibility for the data analysis. Compared to the usual O/D reports, this tool included different parameters to permit the data analyser to dynamically select the period and the kind of data required, the type of report and dashboard that would result.

In conjunction with the Authority, we identified the major topics to tackle in order to improve the quality of the services that are delivered on a day-to-day basis:
- How to better secure the regularity of the tram services and avoid/limit delays
- How to modify timetables and tram operations to optimize tram occupancy
- How to reshape the overall design of services to limit the impact of hyper peak periods

We then decide to specifically tackle the cases of:
- How to solve overcrowded situations
- How to reshape the overall design of services to limit the overcrowding impact of hyper peak periods

As an output, it would illustrate the different options that may be identified thanks to big Data Approach vs the usual scenarios. In such situation the usual options are to put more trams in operation to absorb the overcrowding. This is costly since it results in a change to the maintenance organization and a requirement to hire more drivers and to use reserved trams, or purchase new ones.

For this analysis, we combined two types of data
- Data from operations log book which describes the real position of trams compared to timetables
- Data from validation of smartcards at every station

The combined analysis generated the real time occupancy of every tram, at every station. In this specific Casablanca Case, we identified what was the real morning “hyperpeak” period (Red cells). That “pain point” is only 40 minutes long and for only half a dozen of the stations. That is very limited compared to the low or middle occupancy periods (green cells).

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scenario was able to generate 20% of free capacity during the hyper peak period and without any additional costs: more drivers, more kilometres, or more rolling stock.

As a result, all the over occupancy of the platforms and vehicles disappeared and this option is sustainable enough to support a ridership increase of approximately 10%.

CONCLUSION

Our expectations about Big Data enabled us to develop the process from a technical “back office” analysis approach to a more rapid, interactive, “front office” one, and thus become more transparent and useful as a decision-making tool. Initially, this seemed to be a significant challenge due to the volume and heterogeneity of these new data.

The Proof of Concept clearly demonstrated all the benefits of Big Data and the results exceeded all our expectations. However, during the Pilot we also identified another unexpected challenge; the handling and treatment of this large set of information requires new logic to think, organize, watch and interact with these data, and then to represent the results in order to assist decision support tools.

Going forward, this will require a greater involvement of data managers in the quality, storage and transport of liable data.