

TRANSPORT DEVELOPMENT - REVIEW AND CHALLENGES

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ABSTRACT

Nearly 90% of our daily commuter trips is made on public transport services. Why is Hong Kong doing so well and what conclusions we can draw from our experiences. The main characteristic of our public transport services is that they are market driven. Government acts as the regulator, it provides no direct subsidy. The market responsiveness of public transport operators has meant that the level and standard of our public transport services are maintained and upgraded continuously. Government's role is to provide operators with the right motivation and to maintain a level playing field for different operators to compete for the respective share of the market. The commuters, at the receiving end, expect good quality services provided at reasonable fare and that they have the choice.

**EVOLVING RELATIONSHIPS AMONG OPERATIONS PLANNING,
OPERATIONS CONTROL, PASSENGER INFORMATION AND FARE PAYMENT
IN THE URBAN PUBLIC TRANSPORT INDUSTRY**

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ABSTRACT

Improving performance of computers and communications technologies are now starting to have a significant impact on the urban public transport industry. Automatic data collection systems including automatic vehicle location systems, automatic passenger counting systems, advanced passenger information systems and electronic fare payment and ticketing systems are becoming ubiquitous in large systems and are having an impact on the quality and availability of information for service and operations planning, controlling the service and measuring the resultant service quality delivered to passengers. While the impacts of these advances are already apparent in many systems, there is the potential for much deeper impact in the future. Technology continues to improve across the board and will offer opportunities to develop and apply more ambitious models to assist in many facets of the performance of public transport systems. Traditional models of the inter-relationships between service planning, operations control and passenger information, for example, have been based largely on the independence of these functions one from another. So the service plan has largely driven both the operations control and passenger information functions in most operating agencies, simplifying these aspects of the system. In the future, public transport systems may be able to take advantage of improved information and better communication between operating personnel, agency managers and passengers which will enable a rethinking of these inter-relationships. This presentation will examine current public transport industry practice in this arena and discuss the potential for future enhancement of these individual public transport agency functions as well as their inter-relationships.

PUBLIC TRANSPORT ANALYSIS: BACK TO BASICSS.C. (Chan) WIRASINGHE^a and U. VANDEBONA^b^a *University of Calgary, Calgary, CANADA, Email: chan.wirasinghe@ucalgary.ca*^b *University of New South Wales, Sydney, AUSTRALIA,**Email: U.Vandebona@unsw.edu.au***ABSTRACT**

Analysis of public transport systems appears to be very advanced with a significant literature analyzing whole networks. Breakthroughs in optimization techniques have paved the way to tackle complex objective functions associated with this field. There is also a major body of literature and series of conferences on detailed day to day operational issues such as crew scheduling. We point out two significant issues related to the above activities.

First, given that many of the public transport system analyses are based on some schedule properties being known, should more attention be given to the basic assumptions behind planning of schedules? Second, should the time frame be considered in network analysis, for example, are the time frames for which the schedule and the route structure are planned the same?

We discuss briefly the basic assumptions behind schedule planning philosophies, and argue that the “square root rule subject to capacity constraint” should be used in initial schedule development. We provide some simple examples of other planning activities that are based on getting the schedule right.

We discuss the thinking that should underline the design of a single route, point out that an optimal route does exist, and discuss the issues related getting the design of one route right before we go on to design route networks. Exploring different corridors and their demand coverage has shown us that route selection needs to specifically account for passenger-km to derive meaningful outcomes. We point out the importance of the cost of access to bus stops in path selection. Another important input for the path selection is the estimated passenger demand. We discuss opportunities to apply data collection innovations for reliable estimation of public transport demand.

RAILWAY DEVELOPMENT IN HONG KONG

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ABSTRACT

The Chief Executive's 2007 Policy Address and the December 2007 Rail Merger established the Government's support for the next generation of railway extension projects to be undertaken by the MTR Corporation Ltd.

Five new railway extensions, viz the West Island Line (WIL), the Kwun Tong Line Extension (KTE), the South Island Line (East) (SIL(E)), the Shatin-to-Central Link (SCL) and the Express Rail Link (XRL) will introduce some 60km of rail lines to the MTR rail network and will further expand the rail market share for domestic as well as cross boundary public transport.

The WIL and KTE will be extensions of existing MTR urban lines, to serve population centres in Western District and Whampoa Gardens respectively, which are not currently provided with rail services.

The SIL(E) will provide a new rail link to Ocean Park, Wong Chuk Hang and two further stations on Ap Lei Chau, from an enhanced Admiralty Station, where interchange with the Island Line, Tsuen Wan Line and future SCL will be provided.

The SCL will comprise a new rail line in East Kowloon, joining the Ma On Shan Rail Line at Tai Wai to the West Rail Line at Hung Hom. In addition the East Rail Line will be extended from Hung Hom across the harbour to Hong Kong Island. East Kowloon will therefore be provided with a rail service and the cross harbour rail capacity will be significantly expanded.

The XRL will connect Hong Kong to the new dedicated high speed passenger rail network now being constructed on the mainland. This network will consist of 12,000 km of new rail lines by 2020, linking all the major cities in the mainland.

The above rail projects are being executed in parallel and on a fast track programme. Construction is expected to start in mid to late 2009. The project scope, key issues and challenges ahead are significant.

The projects are expected to make a significant contribution to the economic development of Hong Kong and generate significant new employment opportunities both in the short term and long term, as well as support the drive to sustainable transport in Hong Kong.

**PUBLIC-TRANSPORT CONNECTIVITY MEASURES AND PERFORMANCE
WITHIN THE OPERATIONS PLANNING PROCESS**

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ABSTRACT

The motivation behind this keynote Lecture is to emphasize one subject of public-transport planning to help bridging between the world of practitioners and the world of research and academia for the purpose of narrowing the gap between these two worlds. This motivation arises from a recent book (Ceder, 2007) entitled “Public Transit Planning and Operations: Theory, Modeling and Practice”, and the subject is on public-transport coordination and connectivity.

Profound service-design approaches, including well-coordinated service elements, comprise the foundation of any successful bus and any public transit service in many cities worldwide. Improving transit connectivity is one of the most vital tasks in transit-operations planning. A poor connection can cause some passengers to stop using the transit service. From the user perspective, a global approach for attractive public transit service is the minimization of travel and waiting (and possibly walking) times. This, then, becomes a transit-network coordination problem, which utilizes O-D (Origin-Destination) data. In order to allow for an adequate transit coordination, the planners/schedulers want to ensure smooth transfers involving the switching of passengers from one route to another (could be by a different transit mode) without waiting time.

Service-design criteria always contain postulates to improve routing and scheduling coordination (intra- and inter-agency transfer centers/points and synchronized/timed transfers). Ostensibly the lack of well-defined connectivity measures precludes the weighing and quantifying of the result of any coordination effort. This work provides an initial methodological framework and concepts for (i) quantifying transit connectivity measures and (ii) directions and tools for detecting weak segments in inter-route and inter-modal chains (paths) for possible revisions/changes. The new measures are used in a case study of Auckland's public transit in New Zealand.

PUBLIC TRANSPORT: WHERE WE ARE AND WHERE WE GO

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ABSTRACT

For many years already public mass transit companies have been in the midst of structural changes mainly triggered by external factors such as privatization and deregulation. They are in contest for passengers in competition with private transit, and the room for fiscal manoeuvre within public budgets is restrictive. Therefore, a general framework has to be developed by the suppliers of transit services enabling them to survive and succeed in competition with private transit – a priority that is imperative given the environmental issues especially in congested urban areas.

The aim of public transit bodies has to be an improved design of the service level to the public primarily realizing not yet exhausted economic potentials. As practical experiences have shown, public transit efficiency and therefore the competitiveness towards motorized individual traffic could be increased by using an integrated approach based on modern information technology in planning and operational control as well as advanced electronic equipments.

We survey major improvements in the above key areas along several lines of research. A primary focus is around the topic of vehicle and crew scheduling, highlighting significant advances in both areas, but also illustrating that very useful and computationally efficient methods are being developed for integrated vehicle and crew scheduling. Next in vehicle routing and timetabling methods are developed and advanced for establishing public transport timetables for railways, ferries, and school buses. For many of these cases, new methods must also be devised to enhance the vehicle scheduling process. Moreover, we see a growing interest in transport service and performance monitoring, operations management and control, and dispatching. These topics reflect recent improvements of transport operations through the use of decision support tools. Additional aspects concern planning of public transport services on all levels. Topics in these areas include network design, optimal fare and tolling policies, line planning, fleet sizing, information management and the level of service for special transit services such as demand-responsive systems. While various improvements have been reported there is also a need to put them into practice (“no systems, no impact”). Moreover, this field of research needs to promote its achievements. Recent advances in this respect are award achievements as well as the new publication outlet “Public Transport.”

Keywords: Public transport, route and timetable planning, vehicle and crew scheduling, operations monitoring, information management.

TRANSIT SIGNAL PRIORITY: PROS AND CONS?

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Providing bus signal priority, usually known as transit signal priority (TSP), at a signalized intersection allows an approaching bus to have priority on using the limited intersection capacity over other vehicles entering the intersection. Bus operators generally like this idea, automobile drivers hate it and traffic engineers argue about it. When automobiles are moving in either the same direction as the bus that gets signal priority, or in the opposing movement if it is the same signal phase, TSP will not affect their stopped delay at the intersection; in fact it may decrease their delays. Other vehicles, those with conflicting movements to the phase requested by the bus, may experience additional delay at the intersection. It is because of these delays that there has been some vocal opposition to implementing TSP at various jurisdictions in the USA.

This talk will briefly review types of priority mechanisms that are available in traffic signal systems and that may be available in future systems. Inclusion of optimal scheduling algorithms within such systems can minimize the additional delays to vehicles in the conflicting movements when TSP is actuated.

Looking at TSP from the transit operators' demand side, bus schedules are set with respect to projected demand on each route and nominal travel times from bus stop to bus stop. These travel times include delays at intersections. Small delays in the operation of the bus fleet, due to, for examples, (a) congestion, (b) passengers boarding and alighting and (c) traffic signal delays, can easily be made up by the bus driver, since there is already some built-in slack time in the schedules and, furthermore, the driver can speed up the bus to meet schedule. So, therefore, in that case it may not be necessary to provide TSP.

On the other hand in some cases, more pro-active TSP decisions may be necessary due to large disruptions to the overall operating schedule, such as

- (1) bus breakdown, in which case a backup bus may be needed from the depot, or a bus that has just completed (or about to complete) its trip becomes the backup bus; or
- (2) A particular high delay stop that requires special service, such as removal of a passenger to an emergency (police or ambulance) vehicle.

This talk proposes a concept for providing TSP to specific buses at specific intersections to facilitate the recovery a schedule disruption by either facilitating the backup bus to reach the disabled bus (and adjusting the subsequent assignment of several buses to scheduled trips) in time, or by assisting the delayed bus to adhere to the planned schedule. Given real-time information available through AVL systems that monitor each bus' position, and sensor information available from ITS infrastructure, and given the planned schedule of all the buses in the network, it is possible to predict when buses will approach each intersection and possible conflicts in phases demanded by the buses. Then, given user defined or state-dependent priorities, it is possible to decide which bus, if any, gets priority at which intersection over which vehicles so that the overall objective function can be optimized. Simulation based results indicate this s a promising approach to mange network wide priorities. Perhaps this concept of proving priorities on demand makes TSP more palatable for planners who oppose it.

A MACROSCOPIC MODEL FOR INTEGRATING BUS SIGNAL PRIORITY WITH VEHICLE RESCHEDULINGPitu B. MIRCHANDANI ^a, Jing-Quan LI ^b and Mark HICKMAN ^c

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ABSTRACT

When a bus breaks down on a scheduled trip, one or more vehicles need to be rescheduled to serve that trip and other scheduled trips. The bus breakdown certainly delays the trip being served by the disabled bus and possibly delays or cancels other trips. The *vehicle rescheduling problem* (VRSP) is to reassign and reschedule the bus fleet to minimize the sum of operating costs, delay costs, schedule disruption costs, and trip cancellation costs. Bus operations may also be improved by *bus signal priority* (BSP), which can reduce bus delays at signalized intersections. If BSP is provided to the backup bus that travels to service the disabled bus' passengers, it may reach the breakdown point more quickly. However, other buses that also pass through the corresponding intersections may be affected by signal priority. Therefore, a tradeoff must be made so that the backup bus can travel faster while other buses are not significantly delayed. A macroscopic model that integrates bus signal priority with bus rescheduling is proposed in this paper. Computational results show that the combination of BSP and VRSP effectively reduces the delay of the backup bus and decreases the delay costs.

OPTIMAL COORDINATION STRATEGY FOR AN INTEGRATED MULTI-MODAL AND MULTI-OPERATOR TRANSIT SYSTEM

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ABSTRACT

Mathematical models for optimising schedule coordination were developed for multi-modal, multi-operator transit services, with model input parameters consistent with operational settings and characteristics of Singapore's transit network. Two network configurations comprising mainstay rail services - lengthwise rail network versus multi-loop grid rail network - with feeder buses were evaluated. Transfers (schedules) were optimised in terms of minimising total costs of transit operators and users, for cases of non-coordination versus coordination through common or integer-ratio headways, as applied to three scenarios of operational policies of cooperation, competition and independence between two multi-modal operators. The results revealed that integer-ratio headway coordination is a feasible and efficient headway coordination operation in a transit system, and cooperation between operators is an efficient strategy that can reduce the total cost of integrated transit system with improved coordination. The results should provide a useful reference when making regulatory policies in circumstances similar to Singapore's transit system.

PARETO EFFICIENT STRATEGIES FOR REGULATING PUBLIC TRANSIT OPERATIONSQiong TIAN ^a, Hai YANG ^b and Haijun HUANG ^c

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ABSTRACT

This paper investigates how the local authorities could efficiently regulate the public transit, which is operated by a private firm. The Pareto-efficiency frontier is derived and three types of regulation strategies, namely Price-cap, Return-on-output and Quantity control, are analyzed and compared. On one hand, although the Price-cap regulation can attract more demand effectively, the private firm will inefficiently supply lower frequency to keep the cost down. On the other hand, both the Return-on-output (ROO) and Quantity regulation are the Pareto efficient strategies, which can work along the Pareto-efficient frontier. Especially, Quantity regulation seems more attractive than ROO for there is no need for the firm's accounting information. Additionally, both the on-platform waiting time and the in-vehicle congestion costs are taken into account to reflect the transit service quality. The derived new demand-frequency correspondence extended Mohring's "Square Root Principle".

Keywords: Transit regulation; Pareto efficient frontier; Quantity control; Congestion cost.

THE INFLUENCE ANALYSIS OF POLICIES TO PUBLIC TRANSIT

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With the rapid economic development in Beijing, conflicts between travel demand and environmental limitation, which includes space, energy, air quality, safety etc., are worsening. In this situation, sustainable and rational traffic mode is needed. In our former research, a sustainable and rational traffic mode for Beijing was developed. In this paper, a series of new transportation policies and strategies is put forward to achieve the target. Some factors influence travelers mode choice are questionnaires and analyzed to find out how to make more travelers shift to PT mode. BL model and SEM model are introduced to formulate the traffic mode split in Beijing. Finally, those models are used in Beijing case study to draw out the policies effect. It is shown there is still a long way to go to the sustainable transportation system in Beijing.

EFFECT OF DRIVING-TIME DETERMINATION AND HOLDING POINTS ON RELIABILITY

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ABSTRACT

This paper presents research on optimizing reliability of urban public transport. A theoretical approach and a case study show the effect of design choices of timetabling on reliability. Analysis of actual data shows that the total travel time is minimized if the 35-percentile value is used to determine the driving time out of historical data. This saves up to 75% of additional travel time due to unreliability for all passengers.

If holding points are applied (and departing ahead of schedule is not allowed), the travel time can be even more reduced. A theoretical and a practical study show that designing 2 holding points, using a 30-60 percentile value minimizes travel time (reduction of additional travel time up to 60%), regarding both the waiting time at the stops and in the vehicle.

INTEGRATED TIMETABLING AND VEHICLE SCHEDULING IN PRACTICE

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*GIRO Inc., 75 Port-Royal Street East, Suite 500, Montreal (Quebec), Canada H3L 3T1***ABSTRACT**

A public transit company's planning process generally involves many steps that include: network design, frequency setting, timetabling, vehicle scheduling, crew scheduling, and rostering. To reduce complexity, these tasks are often tackled sequentially, with each step providing the starting point for the next. However, it is possible to obtain significant savings when multiple steps are combined and optimized simultaneously. This paper discusses the specific problem of integrated timetabling and vehicle scheduling and focuses on the main issues that must be addressed in order to reach viable solutions that can be used in practice.

A MULTI-LEVEL FRAMEWORK FOR GENERATING TIMETABLES IN HIGHLY UTILISED RAILWAY NETWORKS

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This paper proposes a comprehensive timetabling approach, which starts with the commercial description of intended train services and generates a conflict-free detailed schedule. It consists of three description levels and corresponding interfaces that enable a hierarchical divide-and-conquer approach. The starting point is a formal structure for describing the service intention including periodicity information. As typical timetables are neither entirely periodic nor aperiodic, a projection scheme is used to create to an augmented period problem. This augmented periodic timetabling problem is solved first globally on an aggregated topology and simplified safety model, and subsequently refined locally by considering all details of the infrastructure and train dynamics. Finally, the generated periodic conflict-free schedule is rolled out over the complete day to create a production plan fulfilling all requirements specified in the service intention. The validity and practicability of the approach is demonstrated on a real-world case study for the train services currently in place in the Lucerne region, a highly utilised part of railway network in central Switzerland.

THE TSAT ALLOCATION SYSTEM AT LONDON HEATHROW: THE RELATIONSHIP BETWEEN SLOT COMPLIANCE, THROUGHPUT AND EQUITY

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ABSTRACT

London Heathrow is an extremely popular airport, where efficient take-off sequencing is important for ensuring a high runway throughput. Aircraft are usually released from the stands as soon as possible, providing the maximum pool of aircraft at the runway from which to choose from when sequencing. This paper considers the task of predicting the delay that aircraft will experience, so that some of it can be absorbed at the stand before the engines are started, reducing the fuel burn, with consequent environmental and economic benefits. Doing this requires determining the value of a take-off sequence, in order to identify good sequences. This paper considers the trade-off between three mutually conflicting objectives – minimising delay, complying with network departure constraints, and treating aircraft equitably - and provides important insights for use in tuning the system to controller preferences. It also indicates potential benefits for controllers from the implementation of such a system.

MULTI-OBJECTIVE APPROACHES TO INVESTIGATE AIRLINE SCHEDULE ROBUSTNESS: THE 3-OBJECTIVE CASE

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ABSTRACT

This paper investigates extensions of previously introduced approaches for multi-objective strategic robust airline scheduling. The 2-objective approach is extended to 3-objective problems, and a new flexibility pattern that simultaneously quantifies swap feasibility and the “potential for delay recovery” is introduced. Mathematical models are introduced and solution strategies are discussed. Computational results for real world problem instances are provided, and show the feasibility of our approaches.

**STATISTICAL MECHANICS FOR ANALYTIC PLANNING: AN APPLICATION
TO DOMESTIC AIR TRAFFIC IN CHINA**

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*Shailesh J. Mehta School of Management, Indian Institute of Technology – Bombay***ABSTRACT**

Statistical mechanics has shown its usefulness when assessing the topology of many networks, including those of infrastructure. Its principles take into account the large-scale and network-wide effects of changes in its key parameters, which in turn may provide critical input when planning for infrastructure projects. One objective would be to modify the pattern of capacity expansions inside a system to make it less exposed to local shortfalls in demand. To illustrate our point, we shall use domestic air traffic in China: Airports are spatially distributed and they also need to respond to the potential demand that they face locally. Airlines that control parts of the traffic system are identified as agents. A relationship between the agent's behavior and the system-wide level of variance in traffic flows can be established by regression analysis. It is shown how intervention on these agents would reduce negative traffic variance while enhancing a more balanced, less costly growth of the system itself.

INVESTIGATION IN REAL-TIME BUS HEADWAY RELIABILITY MEASUREJie (Jane) LIN^a * and Minyan RUAN^b

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ABSTRACT

In frequently serviced bus routes passengers are more concerned about bus headway regularity than actual punctuality of bus arrival to the schedule. Buses arriving within very small (bus bunching) or very large headway are of particular concern and much less desirable. In this paper, a time-point (stop) level probability based headway regularity metric to measure bus service reliability is first formulated mathematically as a function of bus dwell time, number of stops into the trip, passenger activities (i.e., arrival, boarding, and alighting) and expectation (or tolerance). The proposed metric is then used to evaluate a bus routes operated by the Chicago Transit Authority (CTA), using automatic vehicle location (AVL) data. It is found that the time-point level service reliability declines as passenger activity levels increase or as the maximum passenger anticipated headway decreases (i.e., passengers become more demanding of frequent bus services). It is also found that headway regularity during a bus trip is closed impacted by the dispatching headway. Finally, the policy and practical implications of the study findings to improve bus service performance and increase ridership are discussed.

Keywords: headway regularity, reliability, dwell time, service intensity, dispatching headway, automatic vehicle location (AVL)

**IDENTIFYING RECURRING CONGESTION ON URBAN STREETS USING
AUTOMATED VEHICLE LOCATION-EQUIPPED TRANSIT BUSES AS PROBES**

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ABSTRACT

The application of Automated Vehicle Location (AVL) technologies to public transportation is becoming more prevalent among transit operations of varying scales. Applications could range from off-line planning and management, to real-time operations management and traveler information. In addition, AVL data offer an opportunity to infer traffic conditions on the street network where transit vehicles operate. This study focuses on identifying speed patterns and inferring recurring congested conditions on urban streets where bus transit vehicles operate on a regular basis. Such information is of value for off-line and real-time traffic management and could potentially provide useful inputs to transit planners and operators. A methodology is developed whereby the speed distribution is considered and the lower speed range where congestion manifests itself is focused on. The methodology is applied to actual AVL data where some a priori knowledge of recurring congestion patterns is known. The results indicate an effective identification of recurrent congestion. In addition, the results are compared to those produced by classical hypothesis testing methods, thus, further revealing the value of the developed method and highlighting the limitations of the classical methods. Interpretations of these comparative results are discussed and possible extensions are pointed out.

**ASSIGNMENT-BASED METHODOLOGY TO MATCH AUTOMATED
VEHICLE LOCATION TRANSIT BUS TRIP TRAJECTORIES TO SCHEDULES**

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ABSTRACT

The adoption of Automated Vehicle Location (AVL) technology in public transportation provides the capability to amass rich and large data sets that could be used in various planning and operations functions. One of the challenges reported in the literature in the development of effective analysis tools is to match the vehicle trajectories derived from AVL data to schedules. An optimization assignment methodology is developed to address this problem. The methodology is applied to actual AVL data. The results are compared to those produced by a simple matching approach. The comparison of the results reveals the robustness of the developed method and the limitations of the simple one. Interpretations of the comparative results are discussed and some extensions are pointed out.

**THE RESEARCH OF PUBLIC TRANSPORT POLICY SUPPORT THE
COMMUTER TRAVEL MORE SUSTAINABLE**

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ABSTRACT

Towards a sustainable transportation structure, it's very important to improve the attraction and competition of public transit to solve traffic problems in metropolis all over the world. Firstly, literature reviews about theory and applications of customer satisfaction are introduced. Secondly, CS theory was used in urban transport policy research theoretically and practically. A transit commuter satisfaction CS index model was conceived according to a corresponding questionnaire survey for Beijing. On the base of survey and descriptive statistics, CSI model and SEM model was introduced to deal the CSI evaluation. The model was validated, and the index is computed to be 56.2 by the software Lisrel7.6. Finally, according to application of this model, the importance-satisfaction and the influence of their income were analyzed, and some reasonable advices on transit improving policy were put forward. And further analysis of impact about several strategies is carried through.

INTEGRATED PUBLIC TRANSIT PRIORITY STRATEGIESGiuseppe BELLEI ^a and Konstantinos GKOUMAS ^b

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ABSTRACT

The objective of this paper is the improvement in speed and regularity of transit systems, using operation control strategies taking into account the inherent uncertainty of transit operation. A simulation model of a single transit line is presented and different combinations of holding and priority strategies are evaluated and compared using suitably defined performance indicators. The strategy tested is a combination of multiclass conditional priority and holding. Priority is assumed to be given only by green extension actuated by local sensors and up to two priority classes are considered, in addition to no priority, characterized by different maximum green extensions. The strategy is specified by adjusting the relevant parameters in such a way to reduce the sum of transit passenger journey time and road traffic delay. A sensitivity analysis is performed to account for different transit line specifications.

ASSESSMENT OF PUBLIC PRIVATE PARTNERSHIP MODELS FOR MASS RAIL TRANSIT – AN INFLUENCE DIAGRAM APPROACH

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Tang and Lo (2007) outlines four alternative partnership models between the public sector and private railway company and property developer on provision of mass railway transit services. With nomenclatures following the pattern of BFOOD, denoting ‘Build’, ‘Fund’, ‘Own’, ‘Operate’ and ‘Develop Property’, and subscripts R (rail), G (government) or D (developer) indicating the responsible party, the four alternative models can be represented as $B_R F_R O_R O_R D_{R/D}$, $B_R F_G O_R O_R D_{G/D}$, $B_G F_G O_G O_R D_{G/D}$ and $B_D F_D O_G O_R D_D$, showing the roles of the corresponding parties. In this study, by means of the influence diagram approach, the complex inter-relationships between the roles of the different parties and the variables influencing the accomplishment of the financial, transportation and construction objectives are presented in a systematic and holistic manner. This framework is then applied to identify key issues that decision makers on public private partnering approach should take note of. One should also be cautious that it is not merely the public private partnership model that determines the likelihood of achieving the objectives of a rail transit project, but more importantly, how the different parties exercise their roles in managing the variables that influence the objectives.

TRANSFER BEHAVIOR AND TRANSFER PLANNING IN PUBLIC TRANSPORT SYSTEMS: A CASE OF THE LONDON UNDERGROUNDZhan GUO ^a* and Nigel H. M. WILSON ^b

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ABSTRACT

In this research, a path-choice approach based on travelers' revealed preference is adopted to measure the disutility associated with transfer, or the so-called transfer penalty. It is able to quantify transfer experience in a variety of situations in great spatial detail, and reduce the external "noises" that might contaminate the model estimation. Estimation results show high system-wide transfer penalties in both studies, indicating that transfer experience can have a very negative impact on the performance and competitiveness of public transport. They also suggest that the system-average value has limited applications in planning and operation because the transfer penalty varies greatly across station and movement. Such variation is largely caused by different transfer environments, not by different personal characteristics, attitudes, preferences, or perceptions, at least in the two investigated networks. The results confirm the potential, as well as the importance, of transfer planning in major multimodal public transport networks.

DEVELOPMENT OF A HOLDING CONTROL MODEL FOR REAL-TIME CONNECTION PROTECTIONEui-Hwan CHUNG^a and Amer SHALABY^b

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ABSTRACT

Transfer time is a significant component of transit travel from the perspective of transit users. Although transit timetables among intersecting lines may be properly coordinated, an operational control is necessary to maintain coordinated transfers, which may occasionally be disrupted by unexpected delays of transit vehicles. One possible approach is Connection Protection (CP). It involves holding a transit unit (receiving trip) in order to wait for another transit unit (feeder trip) that is planned to provide a coordinated transfer but has been delayed. This study develops a CP model that specifically focuses on the case of two delayed feeder trips. It incorporates the probabilistic nature of transit operations in formulating the model, and accordingly makes more robust decisions for control. The analysis of the model shows that it can make the appropriate holding decisions according to given conditions, and the model is promising in reducing the inconvenience related to transfers.

THE TRANSFER PENALTY MEASUREMENT OF THE REGIONAL RAILWAY STATIONSHye-ran KIM ^a, Hwang-bae KIM ^b and Jin-hee CHOI ^c

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ABSTRACT

There often exists a trade-off relationship between mobility and accessibility. In improving both mobility and accessibility in the public transportation system, construction of an effective main and branch line system is important; one of the core attraction factors which increase demand is the convenience of transfer facilities. In order to quantify a friction effect generated in the process of transfer, perceived potentially by passengers, a transfer friction measuring model was constructed, which converts the frictions into sensory time using mode choice mechanism of the passengers in regional railroads. A logit model, which passengers choose access mode and transfer path, was made. Using the built model the physical elements of the transfer path were converted into the sensory time. Transfer penalty, estimated from the sensory time, can be made use of as an objective index to compare it with the transfer conditions of transfer centers, as well as to decide priorities for facility improvement.

EMPIRICAL COMPARISON OF URBAN RAIL NETWORK DEMAND MODELS: A CASE STUDY IN THE TOKYO METROPOLITAN AREA

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ABSTRACT

This paper compares empirically the performance of six traffic assignment methods with the same empirical dataset of the route choice. The multinomial logit, structured multinomial probit, user equilibrium, logit-based stochastic user equilibrium, probit-based stochastic user equilibrium, and all-or-nothing assignment are applied to the comparative analysis. The four methods to generate the route choice set are also compared for the stochastic traffic assignment methods. The revealed preference data of urban rail route choice in the Tokyo Metropolitan Area is used for the case analysis. The empirical case analysis shows that the accuracy of probit-based SUE is the best among the methods. However, the probit-based SUE requires the longest computation time among them, which may be too long from the practical viewpoints. It also shows that the heuristics to generate the choice set influences the accuracy while to incorporate the route commonality and the in-vehicle congestion significantly improves the accuracy.

Keywords: urban rail demand, network assignment, Tokyo Metropolitan Area, comparative analysis

FINANCIAL SUSTAINABILITY OF RAIL TRANSIT SERVICE: THE EFFECT OF URBAN DEVELOPMENT PATTERN

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The positive correlation between urban population density and transit service patronage is well recognized, as was ascertained via statistical approaches in previous studies. In this study, we seek to derive some prescriptive results of the relationship between urban population density and the financial sustainability of rail transit service. We consider an idealized metropolitan region with a central business district (CBD) at its center, whose population is distributed according to a certain density saturation gradient pattern. Trips generated from the region to the CBD are either served by the rail service supplemented with feeder buses, or by autos or taxis. We study the sensitivity of urban development density on the financial sustainability of the rail service by examining the supply and demand patterns. Through the analysis, the result sheds light on the threshold urban density required, below which the service cannot be sustained financially. The results also provide guidelines for planning urban developments with financially sustainable rail services.

**INFLUENCE OF VACANT TAXI DRIVER'S CUSTOMER SEARCHING
STRATEGY ON TAXI SYSTEM PERFORMANCE**

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ABSTRACT

A dynamic discrete-event simulation model of taxi service is presented in this paper. Under exogenous customer demand, with real time information on customer/taxi queue lengths at all stations, each vacant taxi driver chooses the best station to go to get customers based on a profit maximization strategy. Using a hypothetical road network and three different customer demand patterns, the effectiveness of the customer searching strategy is investigated.

DESIGN OF EXPRESS SERVICES FOR AN URBAN BUS CORRIDOR WITH CAPACITY CONSTRAINTS

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ABSTRACT

In high-demand bus networks, express services promise benefits for both users and operators, and have proven their attractiveness in systems such as Transmilenio (Bogota) and Transantiago (Santiago, Chile). The design of express services involves defining their itinerary, frequency and vehicle size, yet despite the importance of these factors for the network's efficiency, no published works appear to provide the tools for creating a model that minimizes the social costs of an express system on an urban bus corridor.

This paper presents an optimization approach that minimizes these costs in terms of wait time, in-vehicle travel time and operator cost assuming a known trip matrix. Various optimization models are formulated that can accommodate the operating characteristics of a bus corridor, an origin-destination trip matrix and a set of itineraries that are *a priori* attractive. The models then determine which services should be offered at what frequencies and with which type of vehicles. Finally, they are applied to the real-world case of a bus corridor in the city of Santiago, Chile, and the results are presented and analyzed.

BUS NETWORK DESIGN: PROCEDURE AND APPLICATION IN LARGE URBAN AREAS

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*Dip. di Scienze dell'Ingegneria Civile, Università "Roma Tre", Italy***ABSTRACT**

The paper deals with a procedure for solving the bus network design problem with elastic demand in a large urban area and its application in a real context (city of Rome). The solving procedure consists of a set of heuristics, which includes a first routine for route generation based on the flow concentration process and a genetic algorithm for finding a sub-optimal set of routes with the associated frequencies. The design criteria are addressed to develop an intensive rather than extensive bus network in order to improve efficiency, integration among direct routes and effective transfer points that strongly affect service quality and riderships. The performances of the transportation system are estimated on a multimodal network taking into account the elasticity of the demand.

2-VEHICLE ZONE OPTIMAL DESIGN FOR FEEDER TRANSIT SERVICES

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*Zachry Department of Civil Engineering, Texas A&M University, College Station, TX, USA***ABSTRACT**

Operating in a traditional fixed-route (FRT) or in an emerging demand-responsive (DRC) fashion within residential areas, feeder transit services move customers to/from a transfer point that connects to a major fixed-route transit network. In this paper, we expand our previous research to address the optimal zone design problem faced by planners for feeder transit services with high demands and long length of service area, where a two-vehicle operation is adopted in each zone. By balancing customer service quality and vehicle operating cost, we develop an analytical model to aid decision makers in determining the number of zones in a residential service area. For the FRT and DRC feeder transit, close-form expressions and numerical procedures are employed to derive the optimal number of zones and optimal number of bus stations as a function of the main parameters. Our analytical expressions are validated by simulation runs.

UNDERSTANDING TRAVEL BEHAVIOR OF PUBLIC TRANSPORTATION USER IN INDONESIAN METROPOLITAN AREAS

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ABSTRACT

At present, travel behavior studies majorly employ data from developed countries. As a matter of fact, there are many aspects differentiate the characteristics, behaviors, attitudes, expectations, needs, and perceptions of trip makers between developed and developing countries. It shows a need to conduct study by employing data from developing country, like Indonesia, in developing transport policy. This study has an aim to explore the travel behavior of the user of public transportation in three Indonesian metropolitan areas. This study has explored the behavior of the user in three Indonesian cities, i.e. Jakarta, Bandung, and Yogyakarta. Although the cities have significant different in culture and social-demographic characteristics, the significant different in travel behavior cannot be traced. The travel characteristics are similar, as well as small variations in number of usage. Deeper study is beneficial to corroborate the user in making use of public transport in Indonesian cities in more detail.

Keywords: User, travel behavior, public transportation, urban, transport policy

**ESTIMATION OF BEHAVIOURAL CHANGE OF RAILWAY PASSENGERS
USING SMART CARD DATA**Y. ASAKURA, T. IRYO^a, Y. NAKAJIMA and T. KUSAKABE*Department of Civil Engineering, Kobe University, Rokkodai 1-1, Kobe, 657-8501, Japan***ABSTRACT**

Smart card systems have been spreading globally not only for purchasing general goods and services, but also for fare payment of public transport. When an individual traveller is holding a smart card of public transport, the precise times of his/her passing through ticket gates are recorded in the data base of the smart card system. The longitudinal smart card data of a large number of passengers have been stored and become available for marketing purposes of private companies.

However, those data have not yet been sufficiently studied in transport research area. The aims of this paper are to estimate the behaviour of railway passengers using the smart card data, and to evaluate the effects of train operations. In particular, the analysis is focused on the before and after comparison of travel choice behaviour of passengers when the railway company changed the train time table.

This paper describes how the individual passenger's passing times at the entrance and exit ticket gates are aggregated for a small discrete time interval. Analyzing the departure and arrival time distributions and the travel time distribution, it is shown that the passengers smoothly adjusted their travel behaviour to the new train time table. When the passing times of ticket gates of both origin and destination stations are combined with the train time table, it becomes possible to identify the train that each traveller was likely on board. This paper also proposes a method to assign a passenger to a combination of trains between an origin and destination stations. The method is examined using actual smart card data.

**DESTINATION STATION CHOICE ANALYSIS USING HYBRID CHOICE MODEL
AND SMART CARD DATA**

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ABSTRACT

The destination station choice analysis reveals the behavior of passengers selecting destination station in the given railway network. This paper aims to present a model which can describe passenger's destination choice behavior. A hybrid model which combines lexicographic model and mixed logit model is proposed for destination station choice. The lexicographic rule is described by using discontinues likelihood. The proposed method allows the model application to be practical. Bayesian procedure and Gibbs sampler are used to estimate the parameters of the hybrid model. The proposed model is tested on a smart card data set. The analysis could support the railway operation and real estate investment.

**THE CAUSAL RELATIONSHIP OF THE SERVICE QUALITY OF
TRANSJAKARTA BUSWAY**

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ABSTRACT

The implementation of TransJakarta Busway in 2004 is believed as one of the solutions to provide higher quality of public transportation service in Jakarta. Thus, it is imperative to conduct a study that deeply explores the experiences of the user in making use the mode. This article has an aim to provide an explanation regarding the causal relationship of the service quality of TransJakarta Busway. This study applies questionnaire survey to collect data from the first up to seventh corridor. Structural equation modeling is a tool to develop and analyze the model. It can be concluded that this study is able to show and also test the causal relationships of service quality of TransJakarta Busway, namely image, fact, and loyalty. Moreover, the model also shows the level of priorities of the aspects of service quality based on its degree of importance and degree of satisfaction.

Keywords: Causal relationship, Loyalty, Image, Fact, Quality of Service, Busway

THE EVALUATION OF CUSTOMER SATISFACTION DEGREE FOR PUBLIC TRANSIT INDUSTRY

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ABSTRACT

The paper illustrates a novel evaluation system towards public transit industries. With an eye to the limitations of existing evaluation systems, the new approach takes into account the characteristics of individual passengers and individual bus line. Based on AHP, evaluation system is established and index weight values are estimated. In our new evaluation index system, travel time reliability is regarded as one of the important index. Quantitative value of degree of customer satisfaction can be calculated using fuzzy theory after consistency test. In last section, two case studies are performed by taking surveys and questionnaires in Beijing and Shenzhen to verify that travel time reliability is the most important index out of evaluation indices.

SERVICE QUALITY MEASUREMENT IN URBAN RAIL NETWORKS WITH DATA FROM AUTOMATED FARE COLLECTION SYSTEMS

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ABSTRACT

This paper presents a framework for measuring and monitoring service quality in urban rail networks directly from the large volumes of data produced by Automated Fare Collection systems. When fare policies require exit as well as entry control, the transactions generated by ticketing systems can be used to measure the journey time of individual travelers. In the proposed framework, journey time-based service quality is assessed relative to benchmarks tailored to the specific needs of rail operators and passengers. In a given application, the benchmarks are chosen to (i) reflect either scheduled or historically observed values, (ii) measure average performance or reliability, and (iii) reflect the appropriate level of aggregation. The framework is applied to the London Overground and London Underground rail networks using data from the Oyster smartcard ticketing system. These applications demonstrate that the framework is flexible enough to account for a wide variety of circumstances, and specific enough to provide tangible results that can be of value to operators of large urban rail systems.

EVALUATION OF CONTROLLING MEASURES FOR LIGHT RAIL APPLIED IN PRACTICE

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ABSTRACT

RandstadRail is a new public transport service that offers a high quality service. It is a high-frequency system sharing its track with trams and metros. To offer high-quality service in terms of punctuality and regularity and to make efficient use of the infrastructure, a new control strategy is applied.

Preventing, coping and adjusting are the main elements of this control philosophy.

The punctuality of the vehicle is shown to the driver and the dispatchers see all vehicles with positions and punctuality on a display. RandstadRail has a high percentage of exclusive right of way and priority at traffic lights. Vehicles have low floors and broad doors, which reduces deviations in dwell time.

It is shown that due to the control philosophy, the variability of driving times decreased and the schedule adherence improved. Due to higher schedule adherence, mean travel times of passengers are reduced.

CENTRALIZED VERSUS DISTRIBUTED RAILWAY TRAFFIC CONTROLF. CORMAN^a, A. D'ARIANO^{b, a}, D. PACCIARELLI^b, M. PRANZO^c

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ABSTRACT

Railway traffic experiences disturbances and dispatchers are in charge of rescheduling trains during operations. They perform actions to restore feasibility and limit propagation of delays through the network. To help the dispatchers in such task, the centralized decision support system ROMA (Railway traffic Optimization by Means of Alternative graphs) has been recently implemented to optimize railway traffic within a single dispatching area. This paper presents a novel distributed optimization framework to control trains running in multiple dispatching areas. A coordination layer manages the interaction among local ROMA systems. Models and methodologies are described for traffic optimization and schedule coordination. The centralized and distributed systems are compared by using simple and advanced scheduling algorithms. Extensive computational experiments on a Dutch railway network with dense traffic and under practical statistical delay distributions show the effectiveness of the two systems and different algorithms in terms of computation time and solution quality.

Keywords: Railway rescheduling, traffic optimization, schedule coordination

**ANALYSIS OF BUS BOADING LIMITS REAL-TIME CONTROL STRATEGY:
WHEN AND HOW MUCH LIMITING BUS BOARDING IMPROVE
PERFORMANCE?**

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ABSTRACT

Limiting the maximum number of passengers to board a bus can improve headway regularity and therefore reduce waiting times. This effect should be expected to be more significant on buses facing active capacity constraints. Many cities already have bus stops equipped with specialized personnel in charge of controlling fare evasion and assisting boarding; they could also limit boarding if needed. This paper discuss the conditions under which boarding limits policy can be more beneficial by extending a real time mathematical programming model of buses operating on a transit corridor developed by Delgado et al (2009), to allow for only holding strategy. The results show that, in scenarios of high passenger demand and short bus headway operations, strategies that combine holding and boarding limits perform significantly better than just holding, with savings up to 12%. On scenarios of low passenger demand, the boarding limits policy does not improve performance considerably.

**DOOR-TO-DOOR DRT ASSIGNMENT MODEL CONSIDERING TRAVELLERS
MODE CHOICE**Fumitaka KURAUCHI^a, Min GUO^b and Agachai SUMALEE^c^a *Department of Civil Engineering, Gifu University*^b *Graduate School of Engineering, Gifu University*^c *Department of Civil and Environmental Engineering, Hong Kong Polytechnic University***ABSTRACT**

Through recent developments in information and communication technologies, dynamic monitoring and control of transport systems are technically possible. These technologies enable constructing more flexible and cost-effective transport services which may vary based on travel demand. Since passenger demand for public transports has been declining in rural regions, DRT (Demand Responsible Transport), which provides transport service in response to the requests, is expected to have an important role as new public transport system to fulfill the mobility gap between taxi and bus. The route and departure time of DRT changes according to each reservation. Therefore passenger's mode choice influences on the service level. On the other hand, the mode choice is also influenced by the experienced service level. We need to consider the game theoretic aspect to discuss this issue. This study therefore develops a DRT vehicle assignment model for door-to-door services, which is the most popular service type in Japan.

A GENERAL FRAMEWORK FOR DESIGNING DEMAND RESPONSIVE TRANSIT SERVICE

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ABSTRACT

This study intends to develop a general framework for designing the operational model of DRTS. Demand-side and supply-side influence factors were analyzed. The proposed framework defines four service types, consisting of connection, commutation, community and charity services. In addition, various elements of design, such as vehicle (taxi-based and bus-based), stop (fixed and temporary), route (fixed, deviated, flexible and free), and schedule (fixed, flexible and free) are comprehensively discussed. Such a framework could provide a guideline for the service provider and planner.

MEETING FUNCTIONS AND RETURNS TO SCALES IN URBAN TAXI SERVICESTeng YANG ^a, Hai YANG ^a and S.C. WONG ^b

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ABSTRACT

This paper investigates the properties of an aggregate taxi service model with general bilateral searching and meeting functions, which characterize the meeting frictions between vacant taxis and customers. Two specific issues are analysed theoretically for meeting functions that exhibit increasing, constant and decreasing returns to scales, respectively. First, the market profitability at social optimum is examined, and it is found that taxi services should be subsidized at social optimum only when there is an increasing returns to scale in the meeting function. Second, both service quality in terms of customer waiting/search time and average profit per taxi are examined in relation with taxi fleet size, and a Pareto-improving win-win situation is identified, where an increase in taxi fleet size leads to improvement in both service quality and market profitability. It is found such a Pareto-improving situation emerges if and only if there is an increasing returns to scale in the meeting functions.

SCHEDULING-BASED BUS OPERATIONAL-PARKING SOLUTION

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ABSTRACT

One of the operational problems for urban transit, especially with buses, occurs in a situation in which vehicles need to park at route-departure/controlled/holding stops located on-street; however, because of a lack of parking spaces, the buses block the traffic lane adjacent to the parking bay/lane. This work presents a scheduling-based solution, to this problem, comprised of two-part. First, a scheduling-based design tool is developed for describing the changes of operational-parking spaces available at route-departure points; it is termed surplus function and is based on the known deficit function. Second, using the model developed, efficient procedures are built for eliminating or reducing the impact of lane-blocked situations, through the use of shifting departure times and/or inserting deadheading trips in the timetables. The work concludes with a detailed example and a case study.

OPTIMAL BUS FLEET MANAGEMENT STRATEGIES IN A CONGESTED ROAD NETWORK

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ABSTRACT

A simulation model of car, bus and bus passengers that takes into account the effects of car-bus interactions, bus stop dwell time and bus fleet size constraints on bus system performance is described. Feedback loops are incorporated within the model to ensure consistency in car driver and bus passenger route choice behaviors and bus stop dwell time assumptions. A hypothetical network is provided to demonstrate the feasibility of using this model to evaluate alternative bus fleet management strategies.

USING ARCHIVED STOP-LEVEL TRANSIT DATA FOR ASSESSING BUS OPERATIONS AND EXPLORING OPTIMAL STOP SPACING

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ABSTRACT

With increasing attention being paid to performance and financial issues related to the operation of public transportation systems, it is necessary to develop tools for improving the efficiency and effectiveness of service offerings. With the availability of high resolution archived stop-level bus performance data, it is shown that a bus stop spacing model can be generated and tested with the aim of minimizing the operating cost while maintaining a high degree of transit accessibility. In this paper, two cost components are considered in the stop spacing model including passenger access cost and in-vehicle passenger stopping cost, and are combined and optimized to minimize total cost. A case study is conducted using one bus route in Portland, Oregon, using one year's stop-level archived Bus Dispatch System (BDS) data provided by TriMet, the regional transit provider for the Portland metropolitan area. Based on previous research considering inbound trips over the entire day, the theoretical optimized bus stop spacing was about 1,200 feet, as compared to the current value of 950 feet. This paper builds on previous research and focuses on inbound and outbound trips during peak periods, resulting in optimized spacing of about 1,300 feet. The paper discusses trade-offs and presents an estimate of transit operating cost savings based on the optimized spacing. Given the availability of high resolution archived data, the paper illustrates that this modeling tool can be applied in a routine way across multiple routes as part of an ongoing service planning and performance measurement process.

RELIABILITY-BASED STOCHASTIC TRANSIT ASSIGNMENT WITH CAPACITY CONSTRAINTSW.Y. SZETO^a, Muthu SOLAYAPPAN^b and K. I. WONG^c

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ABSTRACT

This paper proposes a Linear Complementarity Problem (LCP) formulation for risk-taking stochastic transit assignment problem with capacity constraints. A route-based linear programming (LP) reformulation of the LCP formulation is also proposed. A new solution method based on the column generation technique is developed to solve the proposed LP. The solution method utilizes the k-shortest path algorithm, revised simplex method and sorting algorithm to solve the LP and guarantees finite convergence. Numerical results are reported for an example transit network based on Singapore's bus network. Based on the results obtained, the proposed approach is also compared with the congestion cost function approach implicitly capturing stochastic capacity. Sensitivity analysis of parameters involved is also discussed in detail.

**A DYNAMIC FREQUENCY-BASED ASSIGNMENT MODEL FOR CONGESTED
TRANSIT NETWORKS USING PROBIT-BASED STOCHASTIC USER
EQUILIBRIUM**

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ABSTRACT

In this paper, we propose a dynamic frequency-based assignment model for congested transit networks. The model assumes that passengers use travel strategies that can be adaptive over time and graphically represented as hyperpaths. We present a new effective frequency formulation to ensure that on-board passengers continuing to the next stop have priority and waiting passengers can be loaded on a First-Come-First-Serve basis. The proposed model is based on the Stochastic User Equilibrium (SUE) with passengers choosing the strategy which minimizes their personal perceived travel cost. To find a solution, we propose a method of successive averages that uses a Monte Carlo simulation and generates strategies during each iteration by solving a dynamic program.

Keywords: Transit Assignment, Frequency-based, Stochastic User Equilibrium, Travel Strategy, Hyperpath

TRANSIT ASSIGNMENT MODEL CONSIDERING THE INTER-DEPENDENT OF EACH LINE'S ARRIVAL

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ABSTRACT

This paper proposes a transit assignment model considering correlation between vehicle's arrival time at stops. The source of correlation in this model is assumed to be varying travel times on the roads that are used by several services and the inter-dependence of vehicles' arrival time is expressed with a given correlation coefficient matrix. Since it is difficult to calculate the expected waiting time at a stop node analytically if there are numerous services, the waiting time at a stop node is calculated with a Monte Carlo simulation-based method where the correlated random variates follow a given distribution function are generated using dependent random variates which follow a normal distribution and a correlation coefficient matrix. The relationship between the correlation coefficient and the waiting time of passengers at the stop is discussed. Finally, the proposed model is applied to a toy network.

ASSIGNMENT OF WORK SHIFTS TO PUBLIC TRANSIT DRIVERS BASED ON STATED PREFERENCES

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ABSTRACT

Transit agencies periodically assign each of their drivers with a shift describing when and for how long they will work each day in the following months. Since drivers are not indifferent to which shift they receive, transit agencies define different assignment methods often based on driver seniority. This article study and compare different shift assignment policies assuming that the agency has some information regarding the approximate utility that each shift represents to each driver. Additionally, based on a study that analyzes driver utilities for flexible shifts (i.e. in which the weekly number of hours is not distributed uniformly along weekly working days), it shows that implementing flexible shifts offer a win-win opportunity for the agency and the drivers. On one hand drivers improve their productivity; on the other they increment their satisfaction with their job. This is particularly relevant since transit operational costs are strongly dependent on their labor force. Some of the benefits obtained by the firm should finally be captured by the users of the system.

TRAIN DRIVER RESCHEDULING APPLYING ACTOR-AGENT TECHNIQUES

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ABSTRACT

Railway operations are based on an extensive planning process. In particular, crew scheduling is a complex process, see Abbink et al. (2005). After the planning process, the daily plans are carried out in the real-time operations. Preferably, the plans are carried out as scheduled. However, in the real-time operations plans have to be updated permanently to deal with delays of trains and larger disruptions of the railway system. A disruption may be due to an incident, or a breakdown of infrastructure or rolling stock. On the Dutch rail network (more than 5.000 trains per day), on average 3 larger disruptions occur per day. An overview of the disruption management process is given by Jespersen et al. (2007).

The total number of train drivers at Netherlands Railways (Nederlandse Spoorwegen or NS) is about 3000. Each day, about 1000 duties are carried out. Furthermore, at any moment in time, the number of active driver duties at that moment is about 300. Due to a disruption, several trains may have to be canceled. As a result, the planned rolling stock circulation and crew duties are not feasible anymore and must be rescheduled. This paper presents a method based on multi-agent techniques to solve the crew rescheduling problem in case of a larger disruption, and is the result of cooperation between Netherlands Railways (NS) and the D-CIS Lab. The implementation is realized using the Cougar framework and includes actual timetable and rolling stock schedule data and driver duty data.

MULTIPLE DEPOT VEHICLE AND CREW SCHEDULING WITH TIME WINDOWS FOR SCHEDULED TRIPS

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ABSTRACT

This paper considers time windows for scheduled trips in multiple depot vehicle and crew scheduling problems arising in public bus transportation. In practice the two planning tasks vehicle scheduling and crew scheduling are traditionally solved sequentially with the implicit understanding that the scheduled time for timetabled trips remains fix. In order to improve cost efficiency two concepts have been developed over the last years: To get more flexibility while scheduling crews, vehicle and crew scheduling problems are tackled simultaneously; To extend flexibility while scheduling vehicles, variable trip departure and arrival times are considered. Obviously the combination of both concepts promises the largest savings, but likely leads to bursting computational times due to growing problem complexity.

In this work we combine both concepts by extending the integrated vehicle and crew scheduling problem with the possibility to shift scheduled trips within defined time windows. We examine the tradeoffs between solution quality and computational time of different variants of our solution approaches.

GLOBAL SOLUTION ALGORITHMS FOR A TRANSIT ROUTE DESIGNSeungjae LEE^a and Jonghak HAN^b^a *University of Seoul, Email: sjlee@uos.ac.kr*^b *Incheon Development Institute, Email: jhhan71@idi.re.kr***ABSTRACT**

This paper presents a heuristic design approach based on the design of hierarchical transit systems. Since this Bus Transit Route Network (BTRN) design problem leads to have multiple solutions in its nature, some global solution algorithms such as simulated annealing, genetic and tabu search algorithms have been developed in order to find a global optimum. The suggested approach for BTRN has been compared with the existing benchmark results. We have found that our solution is better than the other ones in some network parameters. We have also found that even though the hierarchical transit network design problem leads to multiple solutions, meta-heuristic algorithms such as Genetic, Simulated Annealing and Tabu Search have produced consistent similar solutions.

**ALGORITHMIC APPROACHES TO THE CAPACITATED DELAY
MANAGEMENT PROBLEM**

Michael SCHACHTEBECK

*Institute for Numerical and Applied Mathematics, University of Göttingen, Germany***Abstract:**

Delay management is an important issue in the daily operational business of any public transportation company. When delays occur during the operational phase, the task is to update the timetable in such a way that the inconvenience for the passengers is as small as possible and that all operational constraints are fulfilled. To this end, two types of decisions have to be made: *wait/depart decisions* to decide for each connection affected by a delay whether the connecting train should wait for the delayed feeder train or if it should better depart on time, and *priority decisions* to determine the order in which the two trains should pass a common piece of track.

We compare two classes of heuristic approaches: *priority-based heuristics* and *relaxation-based heuristics*. We prove worst-case error bounds and present numerical results from a case study with real-world data, based on a part of the German railway network.

A STOCHASTIC MULTIPLE AREA APPROACH FOR PUBLIC TRANSPORT NETWORK DESIGN

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ABSTRACT

This paper presents a new approach for public transport (PT) network design. The approach makes it possible to refine and evaluate PT systems more realistically than current approaches without significantly increasing computing time. It provides significant flexibility in aligning PT routes. The approach optimizes different service levels sequentially starting with the fastest service. To reduce computing times, each service level is divided into several planning areas. The approach uses a reduction process requiring comparatively few network evaluations. The reduction process starts with a shortest lines network. Then, lines are deleted, merged or shortened sequentially using ant colony optimization. A genetic algorithm simultaneously optimizes service frequencies and vehicle sizes. During the reduction process operating and travel time costs are minimized. For network evaluations a headway based stochastic multiple route assignment is used. The core of the approach has been tested by applying it to a small benchmark problem.

**EXPLORING USER BEHAVIOR ON THE TRANSJAKARTA BUSWAY
USING THE STATED PREFERENCE METHOD**

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ABSTRACT

Bus rapid transit (BRT) has been implemented since 2004 and currently well known as the TransJakarta Busway. The decision to implement BRT in Jakarta has been believed as the right approach. On the other hand, the future of this BRT's service should be anticipated by conducting a well founded study, as well as before implementing new public transportation, whether it is LRT or MRT. The objectives of this study are to elaborate the user preference in the time the existence of modes competition and to corroborate the reaction of the user when there is a change of service attribute in the future. The model estimate finds that age and income influence significantly the user choice. The analysis also elaborates the effect of attributes changes to the user preference, namely fare, waiting time, and riding time. It illustrates the potential of BRT when competes with LRT and MRT in the future.

Keywords: Busway, Stated Preferences, User Behavior, Multinomial Logit Model

**AN ANALYSIS OF EFFICIENCY OF THE SEOUL'S EXCLUSIVE BUS ROUTES
USING DATA ENVELOPMENT ANALYSIS**Jin-seok HAHN^a, Hye-ran KIM^b and Seung-young KHO^c

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ABSTRACT

This study presumes the efficiency of each route by utilizing data of Seoul's blue bus routes for the first half of 2008 and the DEA model. In the estimation, it is assumed that the number of passengers and profits of each route is calculated by considering the number of buses and stops, travel distance, intervals and management cost.

As a result of the examination of input-oriented BCC model, it is found that two out of 18 evaluated routes have constant returns to scale (CRS) and the rest of 16 routes have increasing returns to scale (IRS). In addition, this study conducted Tobit regression analysis in order to grasp the effect of the elements that were used for the analysis on efficiency points, but due to the shortcomings of data, the results were different from expectations.

Keywords: DEA(Data Envelopment Analysis), DMU(Decision Making Unit), efficiency, Tobit regression

**STUDY OF THE IMPACT OF EXCLUSIVE BUS LANE UNDER HIGHLY
HETEROGENEOUS TRAFFIC CONDITION**

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ABSTRACT

This study aims at formulating an appropriate methodology to study and quantify the possible impact of provision of exclusive bus lane under heterogeneous traffic condition. The quantum of increase in level of service of bus due to introduction of exclusive bus lane was determined using a simulation model of heterogeneous traffic flow, developed at IIT Madras. The impact of introduction of an exclusive bus lane is measured in terms of reduction in speed of other categories of motor vehicles, due to the consequent reduction in road space, over a wide range of traffic volume. The main finding of the simulation experiment is the quantification of the maximum permissible volume to capacity ratio that will ensure a level of service of C for the traffic stream comprising all the motor vehicles, except the buses, on a typical six-lane and eight-lane divided urban roads. This study is also concerned with estimation of the probable shift of the personal vehicle users to bus due to provision of exclusive bus lanes.

FREQUENCY-BASED ASSIGNMENT WITH CONSIDERATION OF SEAT AVAILABILITY

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ABSTRACT

This paper proposes a frequency-based assignment model that considers travellers probability of finding a seat in their perception of route cost and hence also their route choice. The model introduces a “fail-to-sit” probability at boarding points with travel costs based on the likelihood of travelling sitting or standing. Priority rules are considered; in particular it is assumed that standing on-board passengers will occupy any available seats of alighting passengers before newly boarding passengers can fill any remaining seats. At the stop passengers are assumed to mingle meaning that FIFO is not observed as is the case for many crowded bus and metro stops particularly in European countries. The route choice considers the common lines problem and an equilibrium solution is sought through a Markov type network loading process and the method of successive averages. The model is tested on a small example network illustrating the effects of the value passengers attach to having a seat.

THE MULTI-CLASS SCHEDULE-BASED TRANSIT ASSIGNMENT MODEL IN NETWORK WITH UNCERTAINTIES

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ABSTRACT

This paper proposes a new reliability-based dynamic transit assignment model for stochastic networks with multi-user classes. Different passengers' responses to uncertainties in transit network are investigated by distinguishing passengers' attitude toward risks on unreliable travel time. Various sources of uncertainties leading to unreliable passenger travel time are categorized into endogenous and exogenous uncertainties and discussed explicitly. Network uncertainties are considered by introducing safety margin to ensure punctual requirements by different classes of passengers. The schedule-based transit assignment method is adopted for modeling the problem concerned. The proposed model can be formulated as a fixed-point problem, and solved by a heuristic algorithm. The numerical example of a case study in Hong Kong demonstrates the performance of the proposed model and solution algorithm together with some important insights.

**AN APPROACH FOR INTEGRATED DYNAMIC TRANSIT AND TRAFFIC
SIMULATION AND ASSIGNMENT**Mark HICKMAN ^a and Yi-Chang CHIU ^b

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ABSTRACT

Our research is developing an integrated framework for both traffic simulation and multi-modal assignment. The heart of the framework is a simulation and multi-modal dynamic assignment model in which travel decisions are made by individual travelers and vehicular traffic is modeled using a mesoscopic traffic simulation. This model includes a more accurate representation of public transit vehicle dynamics and of vehicle stops and dwell times. Also, this traveler-oriented approach includes an explicit representation of transit passengers. A dynamic transit network assignment is included that considers specific vehicle trips and the reliability of service in the network. This “dynamic transit assignment” captures the assignment of transit passengers to transit stops and routes in the network, using a passenger boarding strategy. This boarding strategy generates a time-dependent hyperpath in the transit network, incorporating stochasticity in the vehicle movements. In this way, the research is developing a true multi-modal assignment and simulation model.

PASSENGERS' SATISFACTION, DRIVER AND BUS SCHEDULING: THE CASE OF LAGOS METROPOLIS BUS RAPID TRANSIT (BRT) SCHEME

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ABSTRACT

Arising from the challenges of public transportation system in many cities of developing countries, the clamour for direct government intervention led Lagos government to embark on the Bus Rapid Transportation (BRT) that used dedicated free segregated lines.

The empirical study on which this paper is based was aimed at evaluating the level of passengers' satisfaction, driver and bus scheduling determinants of the BRT scheme introduced about one year ago. About four thousand (4,000) passengers and eighty (80) drivers of the buses in the scheme were interviewed to determine the passengers' and drivers' satisfaction. With 220 buses and about 500 drivers along three (3) dominant routes in the city, drivers and buses scheduling are still manually done leading to long waiting time. This has implications for the route planning, drivers and buses scheduling of the BRT public transport planning and operations.

CASE STUDIES OF TRAINTRACS UNDER CONTRASTING TRAIN CREW SCHEDULING SCENARIOS

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ABSTRACT

Research and development of bus and train crew scheduling optimization systems at Leeds has been reported throughout the entire CASPT series of workshops and conferences since the 1970s. The work has led to the TrainTRACS system nowadays being used in-house by eleven major train operating companies (TOCs) in UK. The longest user started since 2003. The system has also been heavily used to support rail franchise biddings in UK, Stockholm and Australia. TrainTRACS has demonstrated its versatility for a wide range of train operating environments.

**SOCIALLY ACCEPTABLE ANNUAL HOLIDAY PLANNING FOR THE CREW OF
A LOCAL PUBLIC TRANSPORT COMPANY IN GERMANY**

Sigrun DEWESS

*Dresden University of Technology***ABSTRACT**

We consider the problem of socially acceptable annual holiday planning. A new model is developed taking into account legal, company and driver issues. Among others, it includes capacity constraints concerning different qualifications, holiday entitlements and connections between drivers. For each application for leave benefit values depending on family situations (e.g. driver has children of school age), other social criteria and priorities of applications are defined for each possible day of the application.

The problem is solved by a heuristic two-stage algorithm. In the first stage we assume that applications for leave are approved, resolve capacity conflicts and arrange applications for leave to get a feasible solution with a high benefit. In the second stage we try to improve the gained feasible solution. Computational results show, that instances with up to 10,000 drivers can be solved within a reasonable amount of time.

THE BUS BRIDGING PROBLEM IN METRO OPERATIONS: MODELS AND ALGORITHMSKonstantinos L. KEPAPTSOGLOU ^a and Matthew G. KARLAFTIS ^b

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ABSTRACT

Metro networks provide efficient transportation services to large numbers of travelers in urban areas around the World; any unexpected operational disruption can lead to rapid degradation of the provided level of service by a city's public transportation system. In such instances, quick and efficient substitution of services is necessary to accommodate metro passengers including the widely used practice of "bridging" metro stations using bus services. Despite its widespread application, bus bridging is largely done ad-hoc and not as part of an integrated optimization procedure. In this paper we present and discuss algorithms and models for designing bus bridging routes and demonstrate their application in a real world scenario, from an extensive urban network.

**A BRANCH-AND-PRICE-AND-CUT FRAMEWORK FOR CREW PAIRING
OPTIMIZATION**

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ABSTRACT

We discuss the airline crew pairing optimization problem and present a solution method based on a combination of column and cut generation for solving it. The generated cuts are a subclass of subset-row inequalities. The pricing subproblem is solved by a label setting algorithm with a new backtracking scheme and consideration of the generated cuts. The solution method for the linear relaxation is embedded into a branch-and-bound method with a constraint branching strategy and a new search strategy. We test our method with instances based on domestic flight schedules of a European Airline.

COLUMN GENERATION WITH DUAL INEQUALITIES FOR RAILWAY CREW SCHEDULING PROBLEMS

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ABSTRACT

Railway crew scheduling problem is to determine an optimal crew assignment of crews to each train to minimize the number of crews satisfying set covering constraints for given railway timetable data. Column generation is an effective technique to solve railway crew scheduling problem formulated as a huge set covering problem. The method requires a lot of replications to converge due to degeneracy or excess oscillation of master linear programming problem. In this paper, we propose dual inequalities for railway crew scheduling problems to reduce the number of iterations for convergence. Computational results show the effectiveness of proposed method compared with the conventional column generation method.

PUBLIC TRANSPORT SERVICE FOR WEAK DEMAND AREAS

Timo BERTOCCHI and Uwe KÖHLER

*Institute of Traffic & Transport Planning, University of Kassel, Germany***ABSTRACT**

The public transport service must initiate restructuring measures in the rural sector to adapt itself flexibly to the decreasing traffic demand in the future as a result of the demographic, settlement structure-based and financial developments. The following contribution describes the problems of the public transport offers in the rural sector, and introduces solution approaches for a cost-effective as well as attractive public transport service in the rural areas. In this context, service systems of the regular route public transport, demand-based service systems and combinations of the two are delimited mutually such that deployment conditions for these public transport service systems can be defined, giving due consideration to service and operation standards.

ARRIVAL TIME PREDICTION MODEL FOR REGIONAL BUS TRANSIT

Andrew Chun Kit WONG, Amer SHALABY and Baher ABDULHAI

*University of Toronto, Canada***ABSTRACT**

Over the past decade, the popularity of regional bus services has grown in large North American cities due to more people living in suburban areas and commuting to the Central Business District (CBD) to work every day. Estimating journey time for regional buses is challenging because of the low frequencies and long commuting distances that typically characterize such services. This research project developed a mathematical model to estimate regional bus travel time using artificial neural networks (ANN). ANN outperformed other forecasting methods, namely historical average and linear regression, by an average of 55 and 30 seconds respectively. However, the ANN results showed over-estimation by 45% to 60%, which can lead to travellers missing the bus. An operational strategy is integrated into the model to minimize stakeholders' costs when the model's forecasted time is later than the bus scheduled time. This operational strategy should be varied as the commuting distance decreases.

THE RAPID TRANSIT ROUTING PROBLEM

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ABSTRACT

In the context of a suburban operating railway company like is Renfe in Madrid, is important to be able to compete with other companies in an open market, for that they must provide a high service for the passengers with high efficient use of the train resource.

The latter requires an adequate rolling stock if not efficient shunting and crew assignment procedures. Those need to know the optimal train routing given a set of trains flowing for specific type. The *train routing problem* determines the route flow for each specific train. The model has been tested in a concrete Madrid line.

**RESEARCH ON PRICING THEORY AND METHOD OF PUBLIC TRANSPORT
BASING ON COST-BENEFIT ANALYSIS**

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ABSTRACT

The economic benefit of the public transport system (enterprise benefit) and social benefit (user benefit) are a contradictory unity, both of which are closely related to with the public transport system the level of service, thus the largest model of enterprise benefit and user benefit could be established. Adding public transport priority, traffic fare rates, public transport subsidies, the time value of customers, and enterprise costs as the constraints, the public transport pricing model of the system benefit optimization can be established based on cost - benefit analysis, to seek identify ways of public transport fares accord with the actual of China urban, to strengthen government supervision of public enterprises, to determine a reasonable subsidies, to improve the quality of public transport services and public transportation share on the basis of ensuring the normal operation of enterprises and practical guarantee the priority development of public transport.

**PARETO-IMPROVING CONGESTION PRICING ON MULTIMODAL
TRANSPORTATION NETWORKS**

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ABSTRACT

This paper determines a Pareto-improving pricing scheme to alleviate congestion in a multimodal transportation network that includes, e.g., transit services, high-occupancy/toll and general-purpose lanes. In this setting, a pricing scheme refers to a strategy for tolling roads and highways as well as adjusting fares on various transit lines. In addition, such a scheme is Pareto-improving if it maximizes the social benefit without increasing travel-related expense of stakeholders that include individual road users, transit passengers, transit operators, transportation authorities, etc. The user equilibrium and system optimum problem in the multimodal transportation network are discussed along with a model for determining Pareto-improving tolls. The latter is formulated as a mathematical program with complementarity constraints. Two numerical examples are presented to illustrate results from various models.

ROAD PRICING: IMPLICATIONS FOR PUBLIC TRANSPORTTheodore TSEKERIS ^a and Stefan VOB ^b^a *Centre for Planning and Economic Research (KEPE), Athens, Greece, Email: tsek@kepe.gr*^b *Institute of Information Systems (IWI), University of Hamburg,
Von-Melle-Park 5, 20146 Hamburg, Germany, Email: stefan.voss@uni-hamburg.de***ABSTRACT**

This paper investigates the interplay between road pricing and public transport at both theoretical and empirical grounds. First, the main decision parameters of this interplay are reviewed and appropriate methodological approaches are identified. Next, a set of sustainable policy-oriented strategies, which aim at improving urban public transport ridership and reducing private vehicle use, are considered on the basis of a flexible consumer demand system and evaluated through simulation experiments. These experiments focus on the hypothetical implementation of a national distance-based road charging policy in Greece. The simulation results show that a suitably designed policy package can significantly enhance modal split in favor of public transport without significantly increasing the level of road use charges.

PRE-DESIGN METHOD FOR ADVANCED PUBLIC TRANSPORT SYSTEMS

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ABSTRACT

Vehicle automation allowed the creation of a new generation of urban transport systems which can supply car-like quality of service with Public Transport-like impacts. Small automated collective vehicles running on-demand called Advanced Passenger Transport Systems.

A pre-design method to do a first dimensioning of such systems was developed simulating nearly 3 000 scenarios with a "Dial-A-Ride" software and doing statistical regressions on the results.

The method needs in input: network length, expected demand, vehicle top speed, maximum waiting time and vehicle capacity. In six steps the method gives: number of vehicles, average waiting time, vehicle kilometres, commercial speed, occupancy rate and costs.

The regressions are given for 20-place vehicles, 15 km/h top speed and 1 000 s waiting time CTS. All the R^2 coefficients are higher than 0.75 and in most cases than 0.85.

Empirical validations, made comparing pre-design regressions with other systems data, showed the method gives accurate results.

LOG ANALYSIS OF WEB SITE FOR RAILWAY ROUTE SEARCHShintaro TERABE ^a, Kosuke JYURI ^a and Hisao UCHIYAMA ^a*^a Dept. of Civil Engineering, Tokyo University of Science
2641 Yamazaki, Noda-shi, Chiba 278-8510, Japan***ABSTRACT**

Passengers usually seek cheaper and time-saving routes and want to know when to leave their home or office based on their desired arrival time in complicated railway networks. To meet these needs, Internet services for searching railway routes, e.g., “Trip Planners”, are common. The purpose of this study is to investigate how Internet services for railway route search are used by passengers by analyzing log files. The authors focus on day and time of Web access, designated travel date and time, and origin and destination. Based on the analyses, the number of passengers who accessed the Web site is greater on weekdays during the daytime compared to holidays. Furthermore, the origin–destination matrix obtained from the log of railway route search is different from the census. An analysis comparing the time of the search and the desired departure time shows that users do not search long in advance of departure.

DYNAMIC PASSENGER INFORMATION: AN INTERNATIONAL COMPARISONJoachim R. DADUNA ^a, Erik SCHÜTZ and Stefan VOß ^b

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ABSTRACT

For the customer to accept and use public transport services it is necessary to provide them with up-to-date and complete information. Above-the-line are classical information techniques based on (*static*) planned data, which are usually print media. Below-the-line new technical systems are utilized. These are able to provide dynamic data, based on the actual operations. Modern information and communication technologies can be used to provide the basis for an attractive and customer oriented information. Among the most important elements to provide dynamic information are the *Intermodal Transportation Control Systems* (ITC-Systems) (or *Automated Vehicle Monitoring* (AVM)-Systems). Regarding a powerful information management the following operational functions are of particular importance:

- Continuous data collection for *all* vehicle positions and motions, based on satellite positioning (GPS, DGPS, etc.)
- Continuous planned/actual data comparison for analysis and evaluation of the current operations situation.
- Real-time operational data supply.
- Collection of operational data for long run analysis and to assist future planning and decisions.

The objective of our research is to analyze passenger information in different metropolitan areas under their different *socio-cultural* frameworks and regional influences. For this purpose the three cities Bangkok (Thailand), Hamburg (Germany) and San Francisco (United States of America) were selected as prospective candidate cities for examination. An important part of this study is the underlying AVM-System as well as the nature of the offered information and their provision, for both, road and rail based means of transport. Starting from the description of the current state, possibilities will be discussed, revealing how improved and more up-to-date passenger information can be achieved. This includes the analysis of possibilities to attain an integrated information system connecting different means of transport and operators in the three areas mentioned above. Recommendations for further improvements of the respective systems are deduced.

A NEW ALGORITHM FOR SCHEDULING FLEX-ROUTE TRANSIT SERVICES IN A CONSTRAINT PROGRAMMING ENVIRONMENTBaha' W. ALSHALALFAH ^a and Amer S. SHALABY ^b

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ABSTRACT

Flex-route transit service is emerging as an attractive option to serve low-density urban areas. Scheduling flex-route service, however, is a challenging task because it combines both fixed-route and demand-responsive services. In this paper, we develop a flex-route scheduling system that uses the powerful algorithms of Constraint Programming. The scheduling algorithm is developed for both the static and dynamic versions of the problem. A two-stage algorithm for solving the problem is presented. The first stage creates a schedule using an initial solution algorithm, while the second stage tries to improve the solution through local search, using Constraint Programming techniques. The modelling of the problem was performed in ILOG DispatcherTM. The algorithm was investigated on a set of hypothetical cases. The results show that the proposed scheduling mechanism resulted in very reliable and effective schedules

LOCAL SEARCH HEURISTICS FOR THE TRAIN TIMETABLING PROBLEMSebastian G. KLABES ^a and Kai BOLLUE ^b

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ABSTRACT

The creation of a conflict free annual train timetable is equivalent to allocating the train path request of various railway undertakings on the railway infrastructure. The train paths are requested concurrently by the railway undertakings and conflicts are likely to occur at parts of the railway infrastructure where railway capacity is scarce.

This work addresses the automated creation of conflict free train timetables from the point of view of capacity allocation. Rather than introducing a completely new model, this approach is based on the modelling approach used in sophisticated software tools for train timetable construction. Earlier work showed that the modelling approach is suitable to create conflict free train timetables but the microscopic model leads to a very complex train timetabling problem. Well adapted techniques are necessary in order to solve this problem. Suitable local search heuristics are introduced and their application discussed for the capacity allocation on an existing railway corridor.

**GENETIC AND LOCAL SEARCH ALGORITHMS FOR TRAIN CREW
ROSTERING**

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ABSTRACT

Train crew planning in the UK is performed in a number of stages from a few months before a new set of service timetables comes into effect down to the day of actual operation. This paper focuses on the production of the so-called “base roster”, which is a blue-print from which weekly and on-the-day individual crew assignments are based on. Two approaches using genetic algorithms and local search are compared. The research is in collaboration with a number of UK train operators and Tracsis plc ensuring that real life constraints are taken into consideration and all the tests were carried out using real data sets.