FREIGHT TRANSPORTATION IN CONGESTED URBAN AREAS: ISSUES AND METHODOLOGIES

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Abstract

In this paper, we examine relationships between the structure of fast growing, highly congested urban areas hand their transportation systems, attempt to classify the main issues relative to planning freight transportation in such areas, and survey some possible methodologies that could be used to address them. The case of Shanghai, China, a typical congested urban area with a very fast development rate, illustrate our developments.

INTRODUCTION

The purpose of freight transportation is to move goods from origins to destinations. Economic growth increases these movements and affects the land use of a city. In *Fast Developing Areas (FDA)*, both land use and freight transportation systems are undergoing drastic changes in order to catch up with the strong economic growth. Yet, these turbulence also offers opportunities to re-structure the urban structure and to update and modernize the transportation systems over relatively short terms.

Traffic congestion in urban areas is usually caused by high transportation demand and low capacity facilities and infrastructures. In FDA, the "conflict" between transportation demand and supply for passengers and goods becomes more serious, due to high population density and mixed land uses that result from fast urban expansion and industrial development. Difficulties are even more significant for goods movements due to the general priority policy for passenger movements in urban areas enforced by reserved bus lanes, restrictions on heavy truck movement, and daytime access management. Yet, freight transportation is very important to the economic development, especially in FDA. Thus, how to address this issue constitutes an urgent and difficult problem for city planners.

Typical FDA are second type *Desakota* regions (McGee, 1991), such as the Nanjing-Shanghai-Hangzhou and Hong Kong-Guangzhou regions of China, the Central Plains of Thailand, the Taipei-Kaohsiung corridor in Taiwan, and the Calcutta (India), Bangkok (Thailand), and Jabotabek (Java) regions. Other large, congested cities, such as Seoul and Pusan in South Korea, and Mexico City, that are characterised by high density population and fast industrialisation, are also concerned by the topic of this paper. In such regions, local governments or their authorised organisations (e.g. the City Planning Institutes of China) usually have the authority to control and plan the land use, decide on the infrastructure investments, and make transport policies. They usually have the responsibility to jointly optimise the land use and the freight transportation system of the city with respect to both the supply of transport services (e.g. goods terminal locations, road planning, etc.) and demand for freight movements. Although the magnitude of such power and responsibilities varies according to the political and economic conditions of each country, the interventions of public organisations into the transportation planning play a generally major role.

In this paper, we examine relationships between the structure of congested urban areas and their transportation systems, attempt to classify the main issues relative to planning freight transportation in congested urban areas, and survey a number of possible methodologies that could be used to address them. To illustrate, we use the case of Shanghai, a typical congested urban area with a very fast development rate.

LAND USE AND STRUCTURE IN CONGESTED URBAN AREAS

In densely populated FDA cities where administrative, commercial, and industrial zones are interwoven over the entire territory, strong economic growth often exacerbates congestion conditions in the city. Freight transportation may then becomes a bottleneck for economic growth. On the other hand, economic growth gives city governments the financial means (and often the moral authority) to restructure the urban organisation by investing in various infrastructures, particularly transportation-related, as well as by updating and relocating the industrial structure, modifying the land use rules, and other similar means. Due mostly to historical reasons, city governments in FDA have more power and responsibility to control and plan the land use than those in developed market systems. Therefore, public interventions are dramatically changing the FDA land use and transportation structure.

Structure and characters of congested urban areas

The structure and characteristics of cities vary from one country to another one and change as the economy changes. However, common characteristics may be found. Thus, McGee (1991) has analysed and defined the *Desakota* regions in Asia, of which the second type display many common characteristics with the Fast Developing Areas that are the object of this paper. In the following, we summarise the general characteristics of FDA cities where land use and transportation congestion is a basic problem.

Concentration of people and capital

Countries where fast developing areas may be observed are characterised by a very high concentration of people and capital into a few large urban core cities (McGee, 1991). For example, 78% of industrial licenses issued in India between 1951 and 1971 were concentrated in the four national metropolitan areas of Bombay, Calcutta, Delhi, and Madras (Honjo, 1981).

Bangkok's overwhelming primacy dominates the urban hierarchy of Thailand (Pakkasem, 1981). Ten percent of total population of the country lived in Bangkok and, in 1979, 27 % of the Gross Domestic Product was produced there. Thailand's industrial sector is highly concentrated in Bangkok and the Central Region: the two regions have contributed over 83 % of the total manufacturing output in terms of industrial value added.

Korea started to experience rapid economic growth in 1961. Its benefits, however, were largely concentrated in Seoul (Choe, 1991). Conditions in rural areas, as well as in small and medium-size cities did not improve very much. Consequently more people from all over the country headed for Seoul and a few other large provincial cities, such as Pusan.

In China, the core cities include Beijing, Tianjin, Shanghai, and Guangzhou. They are the industrial and population centers of the country. Thus, from an area of 6,186 km^2 (0.07 % of the country) the1991 Shanghai's gross output of industrial and agricultural value represented some 5.6% of the whole country.

Mono-centric city structure

From a transportation point of view, the reason why most cities in FDA display a mono-centric city structure is that there is little choice but to retain a compact, radial structure in the absence of well developed mass transportation systems and of high quality facilities located in non-centre areas (Fouracre and Turner, 1992). A critical factor in the development of FDA has been the improvement of internal accessibility through the expansion of transportation networks. As population increases in an area, the demand for transportation is intensified; as new transport lines are built into the area, a greater population increase is encouraged, which, in turn, calls for still more transportation (Taafee *et al*, 1974). The mono-centric structure is enforced by such development of the transportation system. We can then identify four city areas (Dimitriou, 1992):

- *Central Business District* (*CBD*) is a high density area for city administration, commerce, and businesses. In some Chinese cities a *Central Retail District* (*CRD*) provides daily consumer goods for residents (Wu, 1990). A CBD usually points to the mono-centre of a city;
- A *Dense City Area* (*DCA*) surrounds the CBD. It is characterised by high levels of resident population, and traditionally organised in neighbourhoods with narrow streets and frequent intersections;

- A *Periphery City Area* (*PCA*) has less density than the *Central Area* made up of CBD and DCA. Most traditional industries are located in PCA. The area has potential to build high capacity road systems and transportation facilities;
- *New Developing Zones* (*NDZ*) and *Satellite Cities* (*SC*) are used for locating new industries, transportation facilities (harbour, airport, railway station, etc.) and residences. Some of these areas are far from the city centre and their accessibility needs to be improved.

Very high population concentration in the central area of the city

The ratio. of a centre area maximum to average population density is usually very high. Table 1 summarises comparative studies given in Chen (1993), Hayashi *et al* (1992), and Song (1989). Song also gives a graph of population distributions in Beijing and Sydney that shows a sharp decrease in population density at the DCA – PCA boundary in Beijing, while the Sydney distribution changes quite smoothly.

Traditional industries distributed widely in the centre area

Due mostly to history, cities in FDA have a lot of traditional industries, such as textile, manufacture, and steel plants, in their centre areas. In Shanghai (Yang, 1993), for example, there were 13,220 enterprises in the city in 1990, of which 5,639 were in ten urban administrational districts. These enterprises represented 55.8 % of the work force and 57.7 % of the industrial value of the city. In average, there were 20 enterprises and 7,485 employees in one km^2. The land dedicated to industries was more than 20 % in the centre.

Table 1 - Comparison of population density distribution of different cities

City	Total pop. (millions)	Average density (persons/km^2)	Max. density (persons/km^2)	Ratio max./ave.
Shanghai	12.87	2,030	50,968	25.11
London	12.1	4,300	11,500	2.67
Nagoya	6.4	6,500	10,100	1.56
Bangkok	7.5	3,700	42,200	11.41
Sydney	n/a	1,100	5,000	4.55

Other phenomena in FDA

Population increase, growth in vehicle ownership and traffic, rising land-use densities, and expanding urban areas, are major phenomena in FDA cities that make the transportation problems complex, difficult, and expensive to address. The fast increase of employment and industrialisation in these areas are the root of these phenomena as illustrated in Hong Kong (Skeldon, 1986), the China Pearl River Delta (Leung *et al*), and Singapore (Rodrigue, 1994). Typically such cities have a total land area dedicated to roads below 10 % and rarely above 15 % of the total city area. By comparison, cities in industrialised countries allocate 15% to 25% of the total land area to roads. This allocation goes up to 30% in newer, lower density North American cities (Dimitriou, 1992).

Strategies and policies in FDA cities

To address the over-concentration problem, many FDA cities are making considerable efforts to decentralise their socio-economic activities. Some encourage the restructuring of the city by developing sub-centres within the city limits and satellite cities beyond (Fouracre and Turner, 1992). In South Korea, decentralising efforts were the government's major central policy for more than twenty years (Kim, 1990). In Thailand, the Fourth five-year Development Plan (1977-81) emphasised, for the first time, the importance of channelling economic and urban growth away from

Bangkok (Pakkasem, 1981). Fouracre and Turner (1992) also list examples in cities such as Delhi, Cairo, Manila, and Jakarta.

The main purpose of building sub-centres and satellite cities is to change the land use by moving the population and employment out of the centre area. More precisely, to move the high density population and heavy industries out of the congested city centre in order to use that space to build roads, light industries, as well as commercial and service facilities. Thus, most sub-centres are located in the periphery area of the city. These developments take time and are influenced by various factors: political regime of the country, city development policies, geographic location, transport accessibility, cultural and historical considerations, etc. The main decentralisation strategies and policies may however be summarised as follows:

- Construction of new satellite cities and developing new zones around the central area;
- Construction of industrial complexes in other regions;
- Establishment of new commercial, shopping, and local district administration centres;
- Relocation of residents to new zones far from the old city centre where renovation construction is undertaken;
- Restrictions on new location of plants and warehouses in the urban area;
- Tax incentives for industries to relocate out of the centre of the city;
- Heavy investment in infrastructure, particularly transportation, in the city;
- Establishment of new deep harbours, airports, railway stations far from the city centre;
- Transformation of old industries into high-added value and high technology industries, and concentration of services and businesses in the centre area.

Classification of FDA planning agencies

The success of decentralisation efforts and the possibility to modify the functional land use in FDA depend highly on the intervention of the city government or other agencies charged with the planning of urban land use and zoning. The degree and ability of FDA public agencies to intervene varies, however, according to their economic and political systems:

- *Planned systems.* Authorised agencies in planned systems have full power to control and plan the land use. They are able to order residents or manufacturers to move out of congested area by providing subsidies. Such systems existed in all cities of China twenty years ago, and still exist in most the cities after the system reforms and open-door policy.

- *Mixed systems.* Many congested areas in FDA operate under mixed economic systems. Planning agencies in mixed systems plan and control the land use. But it is difficult to change the zoning systems by simply ordering the residents or manufacturers to move out of some zones.

- *Market systems.* In a market economic system, governments and public planning institutes also have some power to control the development of the city by using the zoning systems and by controlling, to some extend, the expansion and operation of transportation systems. Because of private land ownership, however, it is much more difficult and expensive to change the land use functions.

Shanghai Case

Shanghai is a typical congested city with a strong economic growth over the past twenty years. In 1991, it had a population of 13.40 millions in an area of 6,186 km^2. Its GNP value was one fourteenth of the total of the country.

Due to continuous efforts undertaken by local and national governments, its mono-centre structure has changed gradually with of development of the Pudong area in the east part of the city. The whole structure has changed, and continues to change, following the building of new arterial roads, airport, railway stations, and harbours. Moreover, the old city is being renovated by moving population out of the centre area to build business and shopping centres. Also, by developing several economic zones, old industries are being replaced with high-added value ones.

The government controls most of the land and has the responsibility to plan the land use and transportation network: it is a planned system. Harbours, airports, and railways are all controlled by the government. The largest trucking company, Shanghai Transport and Communication Bureau (STCB), is a governmental institution as well. With the recent development of a market economy, competition from other trucking firms is growing, however, as illustrated in later sections.

The data used in this paper comes from the middle of the 80's. Over the past ten years, impressive changes have happened to the Shanghai urban development, especially following investments in the road network and infrastructure. However, Shanghai is such a huge and populous city that problems of congestion are still very present and this data may help to understand the situation of congested urban areas.

Shanghai has a colonial history. Several foreign settlements planned and managed the land use and road networks in their own territorial concessions, which resulted in chaotic land use and incomplete road networks. Manufacturing plants were found right at the city centre, and the east-western roads were more developed and connected than south-northern ones. After 1949, all lands have been declared state ownership, and have been used by the city authority, although the current users could construct within the limitation of the authorised plans. The government made heavy investments in repairing and enhancing the road systems.

Since the late 50's, Shanghai has developed rapidly. A significant road infrastructure, the Zhongshan Ring Road, has finally taken shape in 1961; It circles the old city area and connects to the trunk roads linking the satellite towns 20 - 30 km away from the old city. From the 70's to the 80's, the development of the city's two "wings" accelerated. During that period, a major petroleum and chemical town, and a powerful iron and steel production base were established in the south and the north parts of the city, respectively.

Starting in the 50's, the municipal area was regularly enlarged. It reached 230 km^2 in 1984 and is now some 748 km^2 large. From the 80's on, highways and economic development zones have been built to strengthen the economic relations with other cities and foreign countries. The most influent and powerful recent policy concerns the development of the Pudong area, to the east of Huangpu River, where new commercial centres, industrial parks, free trade zones, harbours, as well as a new airport are being established.

With such developments, the city has a very complex land use and complex transportation system. In 1990, 4.74 million people were living and 2.70 million were working in the 93 km^2 of the central part of the city. This translated into a density of 50,800 person per km^2 and 28,900 employees per km^2. The road area per capita was only of 2 km^2 (Chen, 1993).

FREIGHT TRANSPORTATION SYSTEMS IN FDA

For most congested cities in FDA, the problem is not to find goods to move, but to find enough roads and vehicles to accommodate what needs to be moved. The reason is that the transport infrastructure and facilities, suffer from lack of previous and continuous investment, and did not follow the pace of increment in transport demand fuelled by the strong economic growth.

Three types of freight transportation can be associated to a city: a) intercity transportation, usually multimodal, takes place between it and other; b) intra-city transportation, which occurs within the city and is usually dominated by truck movements; c). through-city transportation, which occurs between other cities. In this paper, we focus on the first two since they dominate FDA cities issues.

Multimode intercity freight transportation

Many cities in FDA are situated in developing countries and water and rail transportation is still very important for the huge goods movement between cities. In Shanghai, for example, ocean shipping is the largest transportation mode that moves freight to and from the other ports of the country and international cities. The volume handled reached 139.6 million tons in 1990 (CSCP, 1992). The share of water transportation in moving goods from the hinder land into Shanghai was almost 66%. Like most industrialised cities, Shanghai transported more goods into the city than out of it, at a rate of about 2 to 1, which caused serious problems on transport efficiency. Table 2 summarises the modal distribution of freight moved between Shanghai and the rest of the country.

The most geographical dependent transportation mode, obviously, is the maritime and river transportation. Usually, harbours and ports are close to the heavy industries, traditionally located near the extended city centre area. The railway stations for goods movement are also close to the city centre. The convenience of river ports and rail stations situated close to the centre area results in many warehouses near these facilities and along the transport lines. These modes of transportation are still important for freight transport in FDA.

Table 2 - Hinder land regional freight transport of Shanghai in 1991 (1000 tons)

	Railway	Waterway	Highway	Total	Percentage in direction
Into Shanghai	20390	63509.8	6816.5	90716.3	65.78 %
Out of Shanghai	12260	27521.7	7421.1	47202.8	34.23 %
Total	32650	91031.5	14237.6	137919.1	100.00 %
Percentage in mode	23.67 %	66.00 %	10.33 %	100 %	

Truck transportation is still at a very low level for intercity movements related to Shanghai. In 1986, small trucks weighting less than 6 tons made up about 45.9% of the fleet, middle trucks weighting between 6 and 10 tons 44%, and large trucks weighting over 10 tons 9.4 % (He and Chi, 1993). Between Shanghai and other cities, the total truck trips in 1991 represented 6,735,000, with a 46.5 % empty truck ratio and an average load of only 3.94 tons per truck (STCB, 1991).

With economic growth, truck transportation is increasing very fast, though. Motor carriers have made large inroads into freight moving and handling activities in the area. The result has been to release some of the pressure on rail freight transportation which is out of capacity. But the increase of truck transportation has done more than change the method of conveyance. It has also shifted the location of terminal operations away from the waterfront. On the other hand, the impact on the environment of increased truck utilisation has yet to be measured.

The modernisation of FDA calls for advanced integration of freight transportation systems. For example, railway stations, harbours, trucking terminals, and airports should be connected via a high capacity road system linking the major goods generation and consumption zones. With the development of container transportation (Comtois, 1994; Rodrigue, 1994), such connections between harbour and the land network will provide high quality intercontinental door-to-door services and achieve high efficiency in goods movement. Since the 80's, the international container transportation in Shanghai has increased at the average rate of 23.3% per year (STCB, 1995). The new system will also permit shippers and carriers to achieve economies of scale which is one of the most powerful means available to reduce production and service costs (de Buen, 1992). The development of such a high capacity road system has to consider, however, the possible relocation of freight terminals, harbours, airports, and rail stations, out of the central area and to new development zones or satellite cities. The connectivity of the new facilities, the old infrastructure, and customers should not be endangered.

Intra-city truck transportation

There are huge volumes of freight moved in Shanghai's central and periphery areas and the truck shares are increasing year after year. In 1993, the total volume of goods transported by all modes of amounted to 498 million tons, of which 287 million tons were transported by trucks, about 57.4% of the total volume. There were 324,000 vehicles, of which 31% were trucks. Trucks made some 310,000 trips corresponding to 4 million travelled kilometres (STCB, 1995). Truck transportation was not efficient, however: the mile usage was especially low. Table 3 shows comparisons between different trucking agencies (surveyed on December 25, 1986): government owned *STCB*, Shanghai-based *Non-STCB* firms, and carriers from *Other* parts of the country.

The most important goods transported by truck within Shanghai in 1985 were: construction materials (23.4%), daily consumption goods (23.3 %), and iron, steel and machinery equipment (22.8 %). Meanwhile, food and daily consumption goods made up the bulk of freight transportation within the Tokyo area. This emphasises the difference between developed and developing regions.

Table 3 – Performance comparisons of Shanghai motor carriers

	STCB	Non-STCB	Other
Number of trucks	6,426 (10.2 %)	50,386 (79.9 %)	6,229 (9.9 %)
Goods transported (1000 tons)	187 (39.8 %)	258 (54.9 %)	25 (5.3 %)
Percentage of trucks used	74.5 %	68.0 %	94.8 %
Trips per truck	8.31	3.58	1.6
Trip time per trip (h)	0.49	0.73	2.5
Distance per trip (km)	8.94	11.30	43.77
Miles usage (loaded to total trip distance)	52.6 %	58.8 %	65.5 %

The case of Shanghai illustrates the fact that transportation demand greatly depends on the type of land use. The largest trip generation was observed in zones with industries; this, added to those related to construction sites, generated 45% of the total trips. Moreover, various transportation facilities accounted for 30% of the trips, while public buildings accounted for 24%, mainly in commercial and service zones. Residences only accounted for 1% of the total freight vehicle trips (Chen, 1993).

Goods movement in congested urban areas is a major problem. Economic growth fuels and is fuelled in return by increased freight flows and passenger traffic. Goods and passengers compete for the limited road space, with some priority given to passengers. Many management measures, such as day-prohibited access or licensed-based restrictions for trucks in centre areas, have already been used but, in a long run, yielded little or worse results than improving the transportation system. For example, the night shift truck movement policy implemented in 1989 in Shanghai raised the cost of goods transportation drastically, but did not improve the day time transportation because the "extra" capacity attracted more passenger cars. To improve the movements of goods in congested urban areas needs strategic planning and policies. Such strategies should be based on optimised use of the land and transportation facilities – e.g. new industries, resident area, freight terminals, etc. –, combined to an integrated design of transportation networks.

FREIGHT TRANSPORTATION PROBLEMS AT THE STRATEGIC LEVEL

Strategic planning typically involves the highest level of decision and management, and has long term effects on the development of the system. Freight transportation planning is part of urban planning and has an overall influence on the city economy, as illustrated in Figure 1. Thus, from the point of view of city planning the entire transportation systems should be optimised over the long run, in terms of the spatial distribution of production and consumption of goods - the demand for transportation -, and the supply of transportation facilities, infrastructure, and services.

Transportation

Transportation companies consider the problems differently, however. They are users of the transportation system and providers of transportation services to producers and consumers of goods. Their fundamental goal is to operate efficiently and profitably, and provide good services to their customers. They have neither the power nor the need to control the entire system. This translates into different sets of goals and issues as described in the following.

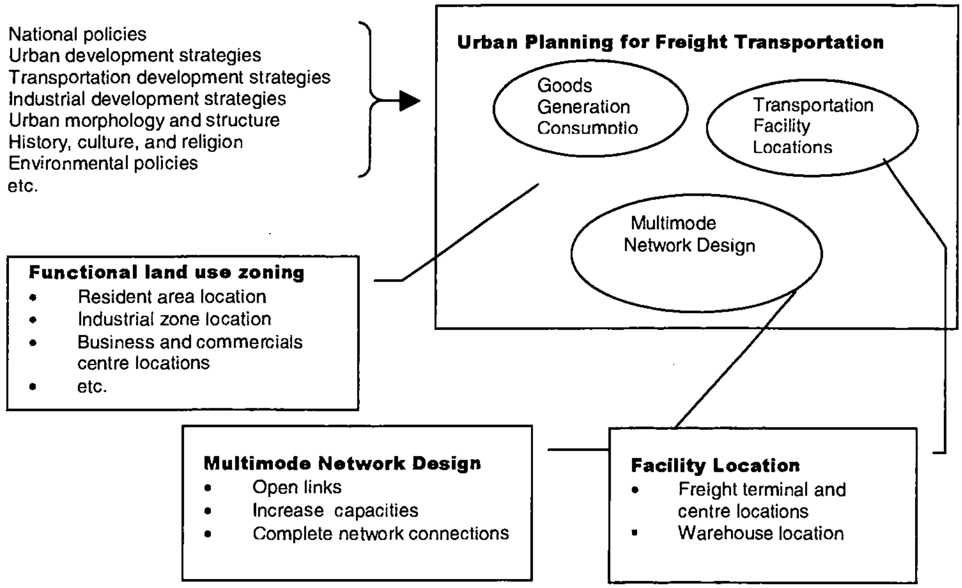

Figure 1 – Freight transportation planning in FDA

Local government issues

- Plan the land use and zoning. This problem is closely related to the broader urban planning issues where the location and distribution of resident, industrial, business, commercial, and administrative areas are considered;
- Locate important transportation facilities, such as airports, harbours, railway stations, intermodal freight platforms, and freight terminals and warehouses. These facilities are the gateways of the city's economy and links the city with other centres within the country and the world;
- Design the freight (and passenger) transportation network to ensure adequate connections within the city, facilitate intermodality, and support intercity transportation;
- Determine and implement policies to manage freight transportation. Given that passenger transportation has first priority, the city government has to be concerned about the trade-off between the competition of trucks for road capacity and their impact on economic growth.

Transportation firm issues

- Location of particular facilities, such as vehicle depots, rail yards, freight classification and consolidation terminals;
- Design of the service network including service routes, frequencies, and schedules, freight routings, terminal policies, and so on.
- Several other strategies and policies relative to the long term evolution of the firm with respect to its various environments; regulatory, financial, labour, environmental, etc.

NETWORK MODELS AND APPLICATIONS

The problems enumerated in the previous section are very complex and may examined form different perspectives. All display a network structure, however, and may thus be addressed by operations research models and method. We briefly review operations research models used in the transportation planning. For a more in-depth treatment of the subject see Crainic (1998, 1999b) and references within.

Location models

Given the demand distribution of customers, location models answer the questions relative to the number, place, size, and demand coverage of the facilities to be located (Daskin, 1995; Mirchandani and Francis, 1990).

Fixed charge facility location models are often used to address issues raised in the freight transportation field. In these models, the fixed costs for opening the facilities at candidate locations and transport costs on the network are jointly considered and optimised. Other models consider the hierarchies of the different functions and services (Moore and Revelle, 1982; Narula, 1986), joint location and routing issues (Laporte, 1988), or the design of the logistic structure of container transportation systems (Crainic *et al*, 1989), to name but a few. Berman *et al* (1992, 1994) consider location issues from different point of view: how to modify the transportation network in order to improve the known location of the facilities.

Facility location problems identified in previous sections can be solved with this class of models. However, these models do not integrate the impacts of land use modifications on goods production and consumption levels and the associated transportation patterns and networks. Thus, the land use and zoning problem expressed in terms of minimising the total transportation cost can not be addressed by the above models.

Network design models

Network design models form a large and important class of problems. Discrete, fixed costs formulations are usually considered for transportation planning applications. In these formulations, network links have both costs proportional to the volume of each commodity and a fixed cost incurred as soon as the link is used. The objective is to satisfy demand at minimum total cost: the cost of the used links plus the cost of moving the freight (Magnanti and Wong, 1984; Minoux, 1989). These mixed-integer models display combinatorial characteristics, complex network structures, and additional constraints (e.g. budget constraints). The difficulty of solving them usually increases exponentially with the size of the network and the number of commodities. Significant progress has been achieved in recent years and a number of important both from a methodological point of view and in applications to transportation planning issues (Crainic, 1999a). Much work is still needed, however, to develop a comprehensive set of tools for network design.

Similar to location models, network design models in the literature consider a fixed demand for transportation. They do not integrate the dynamics of the modifications to transportation and distribution patterns that follow from modifications to the network structure and characteristics. Thus, the current formulations must be enhanced in order to adequately represent the dynamics of FDA, where the goods distribution pattern may change drastically in a relatively short period due to strong economic growth and public intervention.

Traffic Assignment Models

Traffic assignment models attempt to best represent the behaviour of the transportation system and users in order to evaluate scenarios. These models adopt either an user equilibrium or a system optimisation principle to represent travel and operation behaviour. In the former, one assumes that each user attempts to optimise its own itinerary; At optimum, for each origin-destination pair, the average travel time on all routes actually used are equal and less than those which would be experienced by a single vehicle on any unused route (Florian and Hearn, 1995). In the latter, one assumes that the total system cost is minimised. It is usually a generalised cost that includes operating costs, time, reliability, and other factors. At optimum, for each commodity and origin-destination pair, the marginal generalised cost on all routes actually used are equal and less than those which would be experienced on any unused route (Crainic, 1999b).

A number of models and methods based on these ideas have been proposed for the planning of transportation systems, for passengers of for freight. Thus, the STAN model and software (Crainic *et al*, 1990a,b; Guélat *et al*, 1990) have been designed for strategic analysis and comparison of scenarios relative to multimodal, multicommodity transportation systems. This models may be used to analyse a number of issues described previously. But it does not integrate dynamic aspects either.

Service network design models

This class of models are usually aimed at the strategic/tactical planning of operations of intercity freight carriers: railways, less-than-truckload motor carriers, courier services, etc. (e.g. Crainic and Rousseau, 1986; Roy and Crainic, 1992; Powell and Sheffi, 1989). Their goal is to determine the transportation plan and (eventually) schedule to ensure the most efficient and profitable operations while satisfying customer demand and service expectations. Thus, these models are not suitable to address local government issues. They may form the starting point, however, of an effort to develop tools to improve fleet utilisation in intra-city transportation.

CONCLUSIONS

Freight transportation problems in congested urban areas are related to land use planning and economic development. In FDA, interventions of public authorities play an important role in the planning and evolution of these systems, in particular via the development of new residential, industrial, and commercial zones, and the renovation of old city areas. Issues are usually specified as system optimisation in the context of the entire urban area. The solutions influence the development and the structure of the whole city.

Three main sub-problems may be identified, which influence the freight movement of FDA in the long term:

- Land use and zoning. Redefinition of land utilisation, relocation of industrial installations, development of new zones. It influence the patterns of consumption and production of goods patterns resulting in different commodity flows;
- Transportation facility location;
- Transportation network optimisation and service network design that determines the connections between the production and consumption zones use the transportation facilities.

These problems are closely related, especially when city-wide renovation and new development happens related to strong economic growth. There is no suitable model to address these three problems together. Although models for solving each individual problem do exist, as indicated previously, they do not integrate the dynamics linking land use and transportation network design and operation in terms of system optimisation. As for the models that consider the land use and transportation problems together (Hayashi and Roy, 1996), they seldom include a comprehensive representation of the transportation issues and base their land use modelling on individual behaviour theory. This is appropriate in the context of developed market economies, but is generally not suitable for city-wide development with strong public interventions in FDA.

Thus, in order to integrate the public interventions towards optimising the whole system of land use zoning and freight transportation planning, new models and methodologies should be built.

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