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The city-airport connection, implications for urban transport planning in motorcycle-dominated cities

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Abstract

The objective of this study is to propose solutions for in-the-city airport countries where significant conflict between airport-access traffic and pass-by traffic (other urban traffic not accessing the airport) is observed. The study firstly investigates major transport problems of in-the-city airport area. It then reviews different solutions from international studies. The development of transport infrastructure system is proposed with different scenarios and the transport impact assessment is conducted by VISSIM microscopic simulation. The recommendation for city-airport connection is highlighted for the case of Ho Chi Minh city, Vietnam where Tan Son Nhat International Airport locates. The airport separated-access road is proposed for a short-term vision. The study reveals that improvement of transport infrastructure only could not resolve traffic congestion since the traffic demand is much beyond the traffic supply. A multimodal connection and traffic demand management are required for urban traffic in a longer term. The outcomes of this study might benefit urban planners and transport authorities in many cities where motorcycles are dominating.

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Keywords: Tan Son Nhat International Airport, Airport Connection, Urban Transport, Transport Planning

Introduction

In the era of globalized economy and highly dynamic competition for economic activities around the world, airports increasingly represent themselves as the most strategically important transport infrastructure (Harvey, 1987). According to Button and Lall (1999), international airports enhance the economic shift from the main cities towards the urban periphery in metropolitan areas and the surroundings of the airport are one of the most consistently growing parts of the metropolises.

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Tan Son Nhat International Airport is the busiest airport in Vietnam with 32.5 million passengers in 2016 (Airport Corporation of Vietnam, 2016), serving Ho Chi Minh City and the rest of South-Eastern Vietnam. Tan Son Nhat International Airport locates at the center of urban Ho Chi Minh City. Before 1990, Tan Son Nhat Airport was in a suburban area to the north of the urban structure (Fig. 1). After the economic reforms Doi Moi in 1986, economic development has flourished. Urban population has grown rapidly. From 1995 to 2014, the city's population has nearly doubled from 4.64 million to 8.24 million people. In the period 2000-2010, the population growth rate was 3.4% -4% per year.

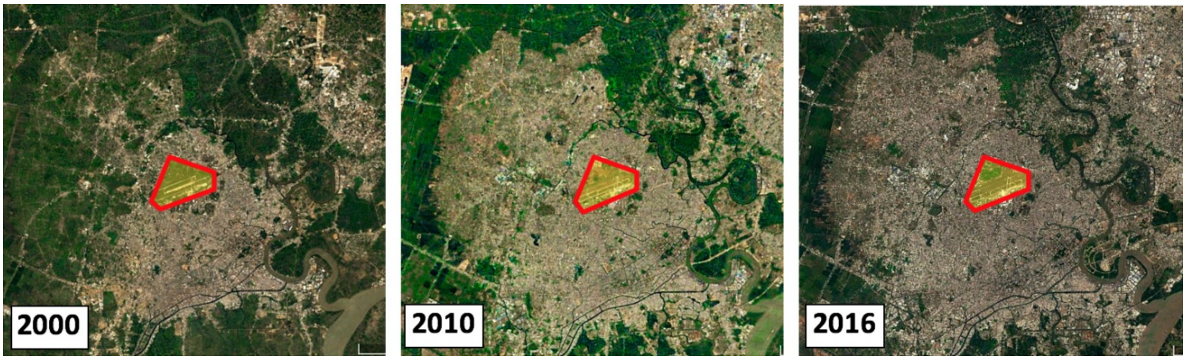

Fig. 1. Urban development at Tan Son Nhat International Airport in Ho Chi Minh city
Source: Google Earth

This rapid expansion can be seen through satellite maps for the year 2000-2010-2016. The urban area has been expanding to the west and the north, which has positioned Tan Son Nhat International Airport in the center of the existing development space of Ho Chi Minh City.

Such location of Tan Son Nhat International Airport has strong impact on urban transport, resulting in significant traffic congestion surrounding airport area. It is observed that the traffic congestion occurs more frequently (5 seriously congestion occurred only in two months in 2017) and in longer time (from 30 minutes on average in 2014 to 2-3 hours or even 6 hours in 2017).

The traffic situation is more seriously in the afternoon peak hour (from 16h to 19h). The vehicles often move very slowly in Truong Son, Bach Dang, Hong Ha which are three major access roads of the airport. The congestion may easily expand to Tran Quoc Hoan, Phan Thuc Duyen, Huynh Lan Khanh whenever a small traffic incident occurs. A typical traffic situation is illustrated in Fig.2 at afternoon peak hour.

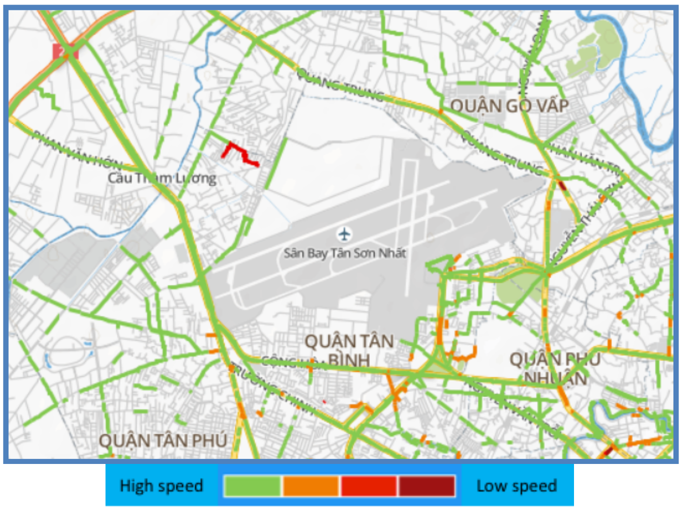

Fig. 2. Traffic situation of transport network at airport area at 17:00h date August 8th 2017

One critical question is how do countries with in-the-city airports respond to a complicated situation of urban transport conflict? What are effective solutions to adapt to the unique condition of motorcycle-dominated cities where mixed traffic is widely observed?

2. City-airport connection from international studies

Airport transport access infrastructure has been investigated in different studies. In 2006, almost 40% of the 150 busiest airports in the word had a rail link connection and 12% were at an advanced stage of planning or constructing a rail link (OECD, 2008). Rail link connection exists in the majority of European large airports while fewer cases are observed in the US (Appold & Kasarda, 2011). It is reported that a fixed track system can attract over 40% of the airport visitors and airports without rail link connections could not achieve public transport shares greater than 30% (Ashley & Merz,2002).

Adequate transport infrastructure linking airports with cities and surrounding areas should increase airport passenger volumes.

Research on new airport locations in Hong Kong (Tam & Lam, 2005), Athens (Psaraki & Abacoumkin, 2002), Beijing (Zhang, Zhang, Zhu, & Wang, 2017) and Kunming (Shi & Ying, 2008) has shown that the relocation of an airport to a site far away from the city makes taxi transport much less practical and increases the importance of public transport. Larger distances appear to be better suited to railway-based solutions. A similar study was done for the TIA MRT system (Taoyouan International Airport Mass Rapid Transit), designed to link Taipei Airport with central Taipei and high-speed rail lines across Taiwan (You et al.2011). Prior to the construction of the TIA MRT system, Taipei Airport was accessible only by road, which created substantial road congestion. In general, the construction of a large airport upgrades the status of a city in the world community (Goldman, 2011). The establishment of flight connections to other major cities is a key step in the development of an airport as a relevant player in the city's overall transport network.

In Great Britain, limited opportunities to build new roads leading to airports along with large increases in airline passenger volume generate excessive road congestions, which also threatens the natural environment (Budd, Ison, & Ryley, 2011). Ecological solutions to the problem of airport road congestion are currently key concerns of Mahashabde et al. (2011), Kaszewski & Sheate (2004), Trzepacz (2010) and Upham, Maughan, Raper, & Thomas (2012). The above papers focus on the need to adopt sustainable development solutions to airport-related problems such as airport-to-city transport, road congestion and toxic emissions.

An example of such solution was the construction of a rail link known as the Heathrow Express Link and the creation of a special bus line for Heathrow employees (Janić, 2011). These two solutions were the first step towards the building of Terminal 5 at Heathrow Airport in London. Some research papers also note the lack of commuting options for airport employees (I Humphreys & Ison, 2002; Ian Humphreys & Ison, 2005). The significance of this issue increases as the status of an airport increases and the number of airport and airport area business enterprises increases. The aforesaid solutions were designed to limit the use of personal transport to access Heathrow Airport.

Many authors have explored the possibility that rail transport may be suitable for city-airport connection challenge. However, rail transport is generally characterized by relatively high fixed costs and high fees for access to rail infrastructure. The study of Kotos et.al. (2012) reveals that bus service remains the primary mode of public transport to and from airports in Central Europe. Special buses serve all airports in this region. Scheduled municipal buses link 42 (78%) airports with the local large cities they serve. However, public transport does not serve more than 30% of passenger volume even at large airports.

In-the-city airports have their unique characteristics regarding the accessibility and the impacts on urban transport development. The conflict between airport-access flow and normal urban traffic flow is the major reason for traffic congestion. Airport rail-link, bus system, light rail, elevated road are different options that might be considered. The questions of what traffic situation of in-the-city airport is and what might be the best solution for such situation will be analyzed and answered in the next sections. Section 3 presents the study methodologies, covering traffic counting survey, vehicle speed measuring, traffic demand forecast, and traffic simulation. Section 4 describes the major results of the study, including the analysis of traffic situation, traffic demand forecast, development of transport scenario and the impact of each transport scenario. Finally, the study concludes in Section 5 by presenting a summary of findings and recommendations to transport authorities and researchers for further implementation and possible future steps for city-airport connection.

3. Methodologies

The flow of this research is shown in Fig. 3. The urban planning and transport planning of Ho Chi Minh City were firstly investigated to see the possible expansion of the city in the next five and ten years. Then the site surveys were conducted for the analysis of traffic situation of transport network surrounding airport area. The site surveys covered six intersections and three road sections, investigating infrastructure and traffic layout, traffic counting survey, vehicle speed measurement, and queue length at the intersections. Car license plate survey was also conducted to measure the exiting directions of cars from the airport. After that the traffic demand was forecasted through the development of the base scenario and the adjusted scenarios, focusing on airport access traffic, urban traffic and area inner traffic. Finally, the transport network was simulated by VISSIM micro simulation to evaluate the impacts of different transport scenarios.

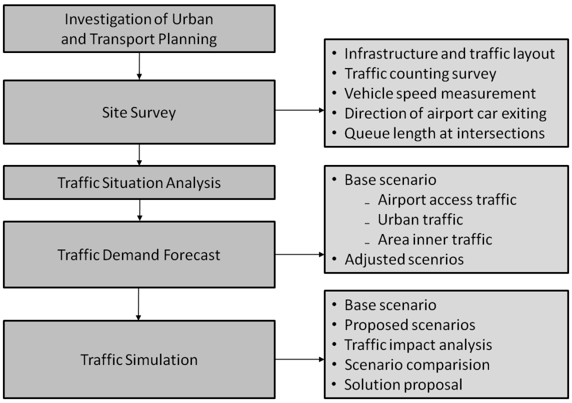

Fig. 3. Research flow

The traffic counting survey was conducted at six intersections, covering all major entry and exit gates of Tan Son Nhat International Airport. The location of research area and six intersections are shown in Fig. 4.

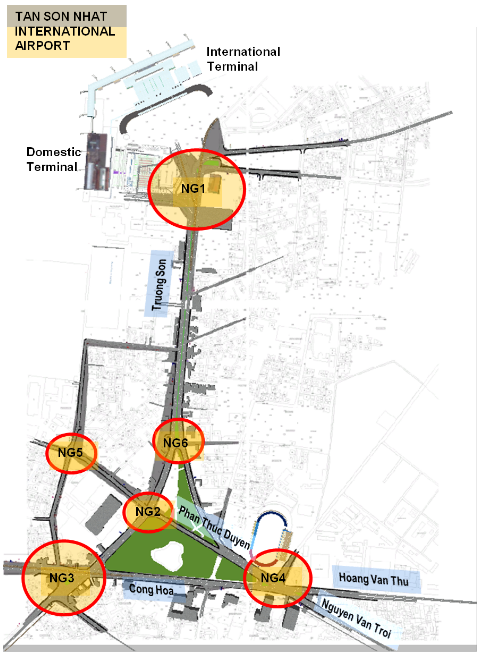

Fig. 4. Research area

The changes of transport infrastructure in time scale are illustrated in Fig. 5.

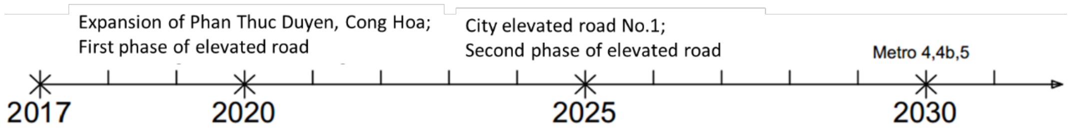

Fig. 5. Changes of transport infrastructure in time scale

Five scenarios are developed for traffic impact analysis (Table 1). They are mostly based on the predicted transport infrastructure improvement with future timescale. The most feasible scenario is the widening of Phan Thuc Duyen and Cong Hoa from 2020. They are two important roads to access to and exit from Tan Son Nhat International Airport. There is also a proposal of an elevated road connecting two airport terminals with Nguyen Van Troi – Hoang Van Thu intersection to operate in 2020 (the Airport Separated-access Road). The City Elevated Highway No.1 (connecting Cong Hoa street with Sai Gon Bridge, the East-West corridor of Ho Chi Minh City) is planned to operate in 2025 and the Metro Line 4B (Airport Line) is planned to operate in 2030.

Table 1. The development of five scenarios

Scenario	Year of Analysis	Description
S0	2017	Existing traffic situation (base scenario)
S1	2020	Without construction of the Airport Separated-access Road With widening of Phan Thuc Duyen and Cong Hoa from 2020
S2	2020	With construction of the Airport Separated-access Road With widening of Phan Thuc Duyen and Cong Hoa from 2020
S3	2025	With construction of the Airport Separated-access Road With widening of Phan Thuc Duyen and Cong Hoa from 2020
S4	2025	With construction of the Airport Separated-access Road With City Elevated Highway No.1 Without Metro Line 4B-1 With widening of Phan Thuc Duyen and Cong Hoa from 2020
S5	2030	With construction of the Airport Separated-access Road With City Elevated Highway No.1 With Metro Line 4B-1 With widening of Phan Thuc Duyen and Cong Hoa from 2020

4. Results

4.1. Traffic situation

4.1.1. Conflict between airport-access traffic and pass-by traffic

Traffic demand in the airport area is composed of two major traffic flows, including airport-access traffic and pass-by traffic (other normal urban traffic not accessing to the airport). Based on the survey data, pass-by traffic accounted for about 80% of total traffic demand in the airport surrounding area, whereas airport-access traffic accounted for only 20%. The dominance of pass-by traffic around Tan Son Nhat International Airport area is a specific feature of the mixed traffic condition in many Vietnamese cities where motorcycles account for more than 80% (Stead & Pojani, 2017). The mode share of urban traffic is presented in Table 2.

Table 2. The share of pass-by traffic at Truong Son road (main airport-access gate)

	Motorcycle (%)	Car (%)	Taxi (%)	Truck (%)	Bus (%)
Day average (24h)	84	62	36	83	97
Morning off-peak (3:00-4:00)	51	52	51	83	0
Morning peak (7:00-8:00)	91	57	1	61	100
Afternoon off-peak (13:00-14:00)	78	59	23	80	100
Afternoon peak (17:00-18:00)	89	67	64	85	100

The high speed of urbanization has increased the need for pass-by traffic around the airport area. In the future, the flow of urban traffic across the airport is estimated to increase rapidly. The conflict between pass-by traffic and airport-access traffic is shown in Fig. 6.

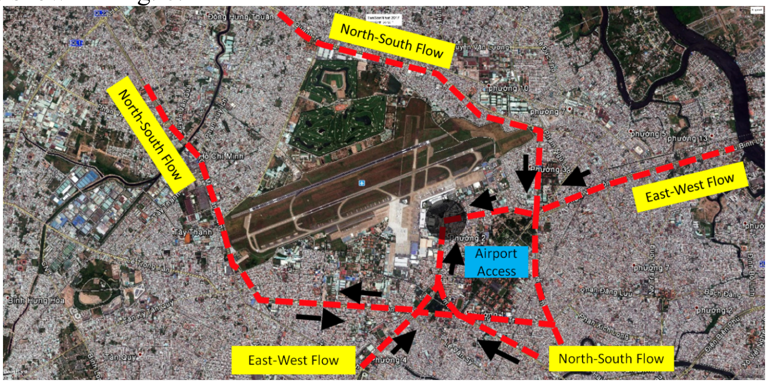

Fig. 6. Conflict between airport-access traffic and urban traffic

4.1.2. The complexity of mixed traffic flow

The dominance of motorcycles is one of the unique traffic features in many big cities in Vietnam. Different transport modes with different sizes and speeds sharing the same lane make the traffic flow conflict.

Road capacity and saturation rate are calculated and analyzed for road sections and intersections in the survey network. The distribution of saturation rate at afternoon peak is illustrated in Fig. 7. The saturation rate pattern is highlighted by colors. Green represents low saturation rate g<0.5, yellow represents medium saturation rate 0.5≤g<0.75, and red represents high saturation rate g≥0.75.

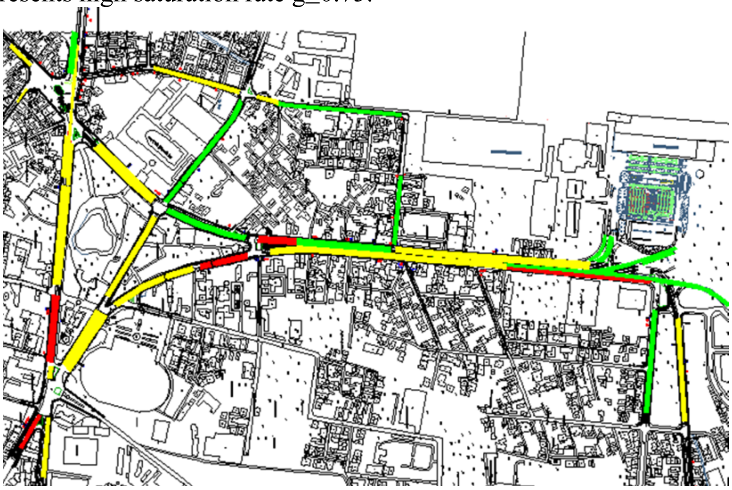

Fig. 7. The level of saturation rate in airport transport network (17h-18h)

At afternoon peak hour, the traffic volume reaches the highest rate. There is a major traffic flow travelling from the city center to the suburban. This direction is reverse in the morning peak. High saturation rate occurs at many road intersections, for instance, Hoang Van Thu – Nguyen Van Troi intersection, Lang Cha Ca intersection, Truong Son – Phan Dinh Giot – Huynh Lan Khanh intersection. The saturation rate is highest at Truong Son – Hong Ha intersection since the pass-by traffic volume peaks.

4.2. Traffic demand forecast

The traffic demand is forecasted in 2018-2030 duration and covering six major steps as illustrated in Table 3.

Table 3. Major steps of traffic demand forecast

Step	Description
1	Base scenario, traffic demand is forecasted without limitation of transport infrastructure
2	Adjusted 1, with the limitation of current transport infrastructure (2017)
3	Adjusted 2, traffic demand is forecasted with the changes of transport infrastructure in 2020 (widening of Phan Thuc Duyen street and Cong Hoa street)
4	Adjusted 3, traffic demand is forecasted with the changes of transport infrastructure in 2020 (widening of Phan Thuc Duyen street and Cong Hoa street, operation of Airport Separated-access Road)
5	Adjusted 4, traffic demand is forecasted with the changes of transport infrastructure: (i) widening of Phan Thuc Duyen street and Cong Hoa street and operation of Airport Separated-access Road; in 2020 and (ii) operation of City Elevated Highway No.1 in 2025.
6	Adjusted 5, traffic demand is forecasted with the changes of transport infrastructure: (i) widening of Phan Thuc Duyen street and Cong Hoa street and operation of Airport Separated-access Road in 2020; (ii) operation of City Elevated Highway No.1 in 2025; and (iii) operation of Metro Line 4B in 2030.

Traffic demand is calculated for each scenario and presented in Table 4.

Table 4. Traffic demand forecast at each scenario

Traffic Flow	Scenarios					
	S0	S1	S2	S3	S4	S5
Destination traffic						
Cong Hoa	4,984	5,400	4,489	5,400	19,951	18,075
Hoang Van Thu	2,159	2,975	2,975	3,600	9,183	9,152
Nguyen Van Troi	2,598	3,230	3,230	3,600	2,311	2,480
Departure traffic						
Cong Hoa	2,676	3,627	2,785	4,038	4,846	5,801
Hoang Van Thu	2,582	3,541	4,019	5,543	7,471	6,979
Nguyen Van Troi	1,800	1,800	2,278	2,278	2,070	2,023
Internal traffic						
Truong Son	-	-	5,330	7,101	7,255	7,018
Phan Thuc Duyen	-	-	2,709	4,295	2,417	2,784
Hoang Van Thu	-	-	1,434	2,442	2,589	3,078

Without the limitation of transport infrastructure, the increase rate of traffic demand is between 11%-14% per year in major roads, for instance, Cong Hoa, Truong Son, Hoang Van Thu, Phan Dinh Giot, Bach Dang, Hong Ha, and between 5%-9% in minor roads, for instance, Phan Thuc Duyen, Huynh Lan Khanh, Hau Giang, Le Van Sy, Nguyen Van Troi. The airport-access traffic increases 12% - 14% in 2017-2020 period. From 2020, airport-access traffic does not increase anymore since Tan Son Nhat International Airport will operate in full capacity. Meanwhile, pass-by traffic increases from 7% to 8%.

Considering the current limited transport infrastructure, the inflow traffic in Cong Hoa street has reached its full capacity from previous years. The outflow traffic in Truong Son and Nguyen Van Troi will soon reach the full capacity in 2019. The remaining road sections will not reach full capacity in 2030, however, many intersections reach the full capacity with the reduction of capacity at network intersections.

With the completion of Airport Separated-access Road in 2020 (scenario S2 and scenario S3), it will undertake 32% of outflow traffic in Truong Son. Phan Thuc Duyen – Tran Quoc Hoan elevated intersection will help to share between 22% and 24% of inflow traffic volume from Cong Hoa to Phan Thuc Duyen, and between 16% and 18% of outflow traffic volume. However, the traffic exceeding capacity in Cong Hoa, Truong Son and Nguyen Van Troi has not been solved. The biggest benefit of Airport Separated-access Road is to free airport-access traffic from pass-by traffic.

The operation of City Elevated Highway No.1 in 2025 (scenario 4) will be combined with Airport Separated-access Road (in 2020). The capacity in Cong Hoa will be enhanced. However, the overcapacity situation in Cong Hoa, Truong Son, Nguyen Van Troi at peak hour could not be handled due to the increase of 11% - 14% in traffic volume. In addition, traffic congestion will occur in Hoang Van Thu, Bay Hien, Le Van Sy, Bach Dang, Hau Giang from 2020.

With the completion of Metro line 4B (proposed to be operated in 2030), between 12% and 15% of traffic volume will be shifted to metro. The traffic flow in the roads will be reduced. However, traffic congestion will not be completely solved in Cong Hoa, Truong Son, Nguyen Van Troi, Hoang Van Thu, Bay Hien, Le Van Sy, Bach Dong, and Hau Giang in 2030.

4.3. Transport impact assessment

The study analyses and assesses the impact of transport infrastructure on transport network for each scenario by developing the microscopic model VISSIM. The transport impact assessment flow is illustrated in Fig. 8.

Traffic data is collected by site survey, including physical road network, signal intersection, traffic volume (at peak hour), mode share, and speed. Such data is established as input data for VISSIM model. Then, the behavior of each transport mode at each location is adjusted to ensure that the output data be appropriate with the survey data. The adjusted factors include traffic volume and average speed at major road sections in simulated model.

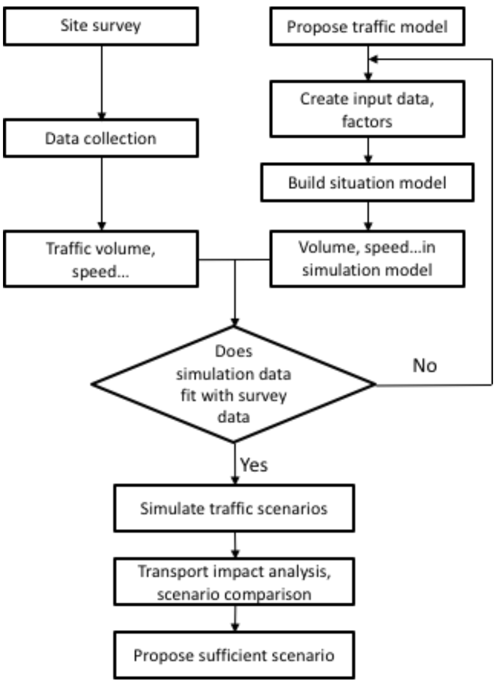

Fig. 8. Transport impact assessment flow

4.3.1. Inputs for the traffic simulation

Table 8 below presents the traffic volume to enter the simulation network. The inputs for traffic simulations include geometry of roads and intersections, road separation and traffic organization, traffic volume and modal splits, traffic signal intersections (number of phases, duration of phases, green time, red time, amber time...), and the movement characteristics of vehicles, for instance, velocity and acceleration.

Table 8. Traffic volume to enter the simulation network at the base scenario (2017)

No.	Entrance		Traffic volume of entrance (vehicle/hour)					
			Motorcycle	Car	Taxi	Truck	Bus	Total
1	Bach Dang		6754	703	536	124	2	8119
2	Airport	Leg 1	0	385	332	59	0	776
		Leg 2	875	359	213	22	1	1470
		Leg 3	85	165	59	14	12	335
3	Huynh Lan Khanh		247	0	0	0	0	247
4	Phan Thuc Duyen		878	83	29	44	0	1034
5	Cong Hoa	Ground	4933	215	64	90	55	5357
		Bridge	8708	715	156	59	0	9638
6	Hoang Van Thu (Bay Hien)		8998	440	199	23	29	9689
7	Hoang Van Thu (East- NG4)		5849	320	82	80	34	6365
8	Nguyen Van Troi		6793	959	365	115	30	8262

4.3.2. Validity of the simulation model

The validity of the simulation model was checked by comparing the outputs of base scenario with the real observation to get required accuracy. The adjusted factors include traffic volume passing through significant sections and the average velocity at the main section of simulation network. Table 9 presents the results of adjusted traffic volume at significant sections of the network.

Table 9. Comparison between simulation outputs and real observation

Section	Section traffic volume (veh/h)		
	Real Observation	Simulation	Difference
Bach Dang	8119	8051	-0.84%
Airport	2589	2221	-14.21%
Truong Son (Cuu Long – Hong Ha)	8184	8212	0.34%
Truong Son (Dong Nai-Huynh Lan Khanh)	9651	8759	-9.24%
Phan Dinh Giot (Pho Quang-Huynh Lan Khanh)	12399	11315	-8.74%
Huynh Lan Khanh (NG6)	247	237	-4.05%
Tran Quoc Hoan (Huynh Lan Khanh-Phan Thuc Duyen)	13366	14887	11.38%
Phan Thuc Duyen (Nguyen Van Troi-Tran Quoc Hoan)	8077	9123	12.95%
Tran Quoc Hoan (NG2-NG3)	22831	20271	-11.21%
Cong Hoa (ground)	5357	5393	0.67%
Cong Hoa (bridge)	9638	8398	-12.87%
Hoang Van Thu (Bay Hien)	9689	7206	-25.63%
Le Van Sy	5641	5660	0.34%
Hoang Van Thu (Eastern- NG4)	6365	6391	0.41%
Nguyen Van Troi (enter NG4)	8262	7795	-5.65%
Hoang Van Thu (Western- NG4)	20511	17998	-12.25%
Total	150926	141917	-5.97%

The traffic volume and the velocity are compared between the real observation and the modified simulation model. It can be concluded that the calibration model is reliable and can be used to design the alternative traffic scenarios in the future.

4.3.3. Alternative scenarios

From adjusted simulation model, alternative scenarios are developed under many traffic organization circumstances in the future. Such scenarios are then analyzed and compared. Table 5 illustrates five scenarios which accordingly presents five improvement to be tested in the VISSIM simulation. The base scenario is developed for current situation in 2017.

The alternative scenarios are assessed at peak-hour period. Such duration covers the highest number of traffic volume entering the transport network. Transport simulation and transport analysis at peak hour will ensure the best impact assessment of each transport scenario, transport infrastructure development and transport organization. The assessment specially focuses on the impact of airport-separated access road on the transport network.

Table 5. Alternative scenarios

Scenarios	Year of analysis	Improvement to be tested in the VISSIM simulation
M0	2017	Base scenario. The input data is collected by site survey. The base scenario is limited with major intersections.
M1	2020	With the expansion of Phan Thuc Duyen, Cong Hoa from 2020
M2	2020	With the expansion of Phan Thuc Duyen, Cong Hoa from 2020; With the completion of airport separated access road in 2020
M3	2025	With the expansion of Phan Thuc Duyen, Cong Hoa from 2020; With the completion of airport separated access road in 2020
M4	2025	With the expansion of Phan Thuc Duyen, Cong Hoa from 2020; With the completion of airport separated access road in 2020; With the completion of City elevated road No.1
M5	2030	With the expansion of Phan Thuc Duyen, Cong Hoa from 2020; With the completion of airport separated access road in 2020; With the completion of City elevated road No.1; With the completion of Metro Line 4B1 (connecting city centre with Tan Son Nhat International Airport)

4.3.4. Assessment results

Table 6 presents major results for the assessment of alternative scenarios.

Table 6. Transport impact assessment for alternative scenario

Assessment Indicators	M0	M1	M2	M3	M4	M5
Delay time of each vehicles [s], All modes	362.67	650.53	502.35	619.24	638.22	684.16
Average speed [km/h], Motorcycle	10.91	4.33	6.32	4.91	4.65	4.05
Average speed [km/h], Car	8.71	3.97	6.07	5.18	7.87	7.49
Total travelling time [h], All modes	11,511.01	22,211.71	19,115.36	22,649.34	24,998.51	26,729.04
Total vehicles exiting from network (all modes)	67,101.00	72,972.00	85,186.00	81,237.00	88,172.00	86,049.00

In the M1 scenario (2020), many performance indicators are reduced compared with M0 scenario (2017). Worse performance indicators are observed with four-wheel vehicles, for instance, highest delay time, lowest travel speed, longest travel time. It could be concluded that the congestion situation is much worsen if there is no transport infrastructure improvement (without new airport separated access road). Four-wheel vehicles have the highest level of impact.

With the completion of airport separated access road (in 2020), the performance indicators are improved significantly in the network. This is evidenced by comparing M2, M3, and M4 scenario with M1 scenario. Therefore, transport infrastructure improvement (with new airport separated access road) facilitates the reduction of traffic congestion.

However, the performance indicators will get worst in M5 scenario in 2030. There would be the highest delay time (all vehicles) and the lowest speed (motorcycles). A major reason is M5 scenario is developed for 2030 timescale when traffic demand reaches its highest level. Even though the transport infrastructure is improved (including new airport separated access road, new City elevated road No.1, completion of Metro Line 4B), it could not meet all mobility demand.

Table 7 also presents the impact assessment for major intersections in the airport area. The results similarly show that the impact level is different at each intersection.

Table 7. Transport impact assessment at major intersections for alternative scenarios

Intersection	Indicators	Leg	Unit	Alternative scenarios					
				M0	M1	M2	M3	M4	M5
Truong Son - Hong Ha - Bach Dang Intersection	Traffic volume		xe/h	18,484	12,513	21,356	23,278	24,561	26,826
	Delay time		s/xe	56	226	118	125	128	133
	Queue length	Bach Dang	m	93	213	42	50	54	57
		Truong Son		19	-	-	-		-
Nguyen Van Troi – Hoang Van Thu Intersection	Traffic volume		xe/h	30,840	25,173	34,361	31,999	36,224	35,735
	Delay time		s	92.4	199.2	148.4	177.6	148.5	195.5
	Queue length	Haong Van Thu (EB)	m	108	414	344	725	376	393
		Nguyen Van Troi		353	625	579	912	575	612
		Hoang Van Thu (WB)		58	480	186	672	180	198

The improvement of transport infrastructure leaves the highest impact on airport main entrance intersection (Truong Son – Bach Dang – Hong Ha). The performance indicators in M2, M3, M4, M5 scenario are much better than those in M1 scenario. A major reason is four-wheel vehicles shifting to the new airport-separated road. Therefore, the remaining traffic volume in other intersections significantly reduces. The capacity of transport network hence increases.

However, the output data also reveals that not any transport model is better than M0 scenario (base scenario). It means transport infrastructure improvement only leads to better results than the base scenario (without any project). It facilitates road capacity increase but could not completely solve the congestion. Even with the Airport Separated-Access Road (planned to operate in 2020) the City Elevated Highway No.1 (proposed to be completed in 2025) or the Metro Line 4B (projected to operate in 2030), the problem of traffic congestion could not completely be resolved. A big gap between traffic demand and infrastructure supply is the main cause. Therefore, sufficient transport demand management is significantly required.

5. Conclusions and outlooks

The study presents empirical data compiled from the data collection and transport survey at the main network of Tan Son Nhat International Airport. The traffic situation is analyzed, and major causes of traffic congestion are identified. The study also performs the transport demand forecast and transport impact assessment through a microscopic simulation. The changes in transport infrastructure and transport organization are designed in five scenarios which are also simulated in transport models.

VISSIM microscopic simulation that appropriately reflecting the mixed traffic flow in many motorcycle-dominated cities in Vietnam is utilized. Alternative scenarios are designed to capture the improvement in transport infrastructure, traffic flow and transport organization. The results include speed of traffic flow, reduction of travel time, time loss of vehicles on the access routes between the airport and city center. On that basis, the study assesses the reduction of traffic congestion on major access roads and at intersections.

Such analysis confirms that there is a positive impact of transport infrastructure improvement on transport network, regarding the increase in average speed and road capacity, the reduction in delay time. However, the study also reveals that only infrastructure improvement could not completely solve traffic congestion. The construction of transport system could not keep up with a high level of transport demand. A huge gap between transport supply and demand is observed by simulation models. The study emphasizes, once again, that expansion of transport infrastructure could not solve the roots of traffic congestion. To deal with urban transport problem in long-term, it is significant that sufficient transport demand management be considered.

The outcomes of this study might be beneficial for transport planners and transport authorities in many developing countries, especially for in-the-city airport cases. The conflict between airport access flow and pass-by traffic is observed as a major reason for urban congestion. A proposal has been designed for the case of Tan Son Nhat International Airport. An airport separated - access road could be used for a short term. For long-term, a multimodal transport system combined with effective transport demand management strategies are required for city-airport connection.

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