

# APPENDIX 1

## RUNWAY CAPACITY

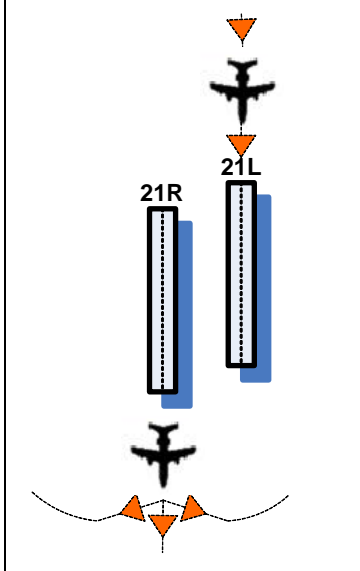
# 1. BANGKOK/BANGKOK INTERNATIONAL AIRPORT

## 1.1 Model 1

### a) Operational Conditions

- 1) Runway 21R is used in departure operation.
- 2) Runway 21L is used in arrival operation.
- 3) Parallel runway separation is 395 m. ( between 21R and 21L )
- 4) Airport Surveillance Radar ( ASR ), scan time 5 seconds.
- 5) Aircraft mix
  - i. Heavy 46%
  - ii. Medium 50%
  - iii. Light 4%
- 6) Approach speeds
  - i. Heavy 150 knots
  - ii. Medium 140 knots
  - iii. Light 110 knots
- 7) Common approach length 7 nm.
- 8) In-trail delivery error standard deviation is 10 seconds.
- 9) Large hub separation criteria. ( 4/5/6 nm )
- 10) During VMC operation.

### b) Model and Runway capacity

	Runway-in-use	Per hour	
		Arrival	Departure
Runway 21R	-	-	29.74
Runway 21L	24.40	-	-
<b>Total</b>		<b>54.14</b>	

1.2 Arrival and Departure Diagram

ARRIVAL - DEPARTURE DIAGRAM.  
VMC CONDITION



**1.3 The estimation, in the event of VMC condition**

**Runway Capacity Estimation**

**ในกรณีสภาพอากาศ VMC**

Technical Parameters(inputs)	Parameter	Values
Dep-Arrival Separation(nm)	$\delta$	2
Common Approach Length(nm)	$\gamma$	7
Standard Deviation of Positon Delivery Error(s)	$\sigma$	10
Probability of Violation	$P_v$	5
Cumulative Normal at $P_v$	$q_v$	1.4

	Light	Medium	Heavy	
ROT(s)	60	75	82	77.62 E(ROT)
Percent Mix	4	50	46	100 Total%
Vapproach(knots)	110	140	150	

	Arrivals-Arrivals			Hub Type
	Trailing			
	Light	Medium	Heavy	
Light	4	5	5	weather Conditions
Medium	5	5	5	vmc
Heavy	6	5	5	

	Trailing			Unit:second
	Trailing			
	Light	Medium	Heavy	
Light	130.91	138.46	124.14	Expected Value
Medium	212.73	138.46	124.14	E(Tij)
Heavy	257.45	140.57	124.14	136.02

	Trailing			Sum of Pij
	Trailing			
	Light	Medium	Heavy	
Light	0.004	0.006	0.005	0.015
Medium	0.006	0.27	0.22	0.50
Heavy	0.005	0.26	0.22	0.49
				1.00

		Trailing			Expected Value
		Light	Medium	Heavy	
Light	14.00	14.00	14.00	$E(B_{ij})$	
Medium	0.00	14.00	14.00	11.49	
Heavy	0.00	5.43	14.00		
	-38.36	-21.06		$B_{ij} = \text{zero if } B_{ij} < 0$	

		Trailing			Expected Value
		Light	Medium	Heavy	
Light	144.91	152.46	138.14	$E(T_{ij}) + E(B_{ij})$	
Medium	212.73	152.46	138.14	147.51	
Heavy	257.45	146.00	138.14	147.51	

Arrivals Only Capacity(per hour) 24.40

Departure-Departure Separation Matrix(nm) unit:second

		Trailing		
		Light	Medium	Heavy
Light	60	90	120	
Medium	90	90	90	
Heavy	120	90	90	

Expected Value	
$E(T_d)$	
91.056	121.056

Free Time for crossing&hold(second) 30

Departures Only Capacity(per hour) 39.54

Summary for Arrival - Departure Diagram

Arrival	Departures
24.40	
24.40	29.74
	39.54

Operation Pattern

- Arrivals Only
- Arrivals100% + Departures
- Departures Only

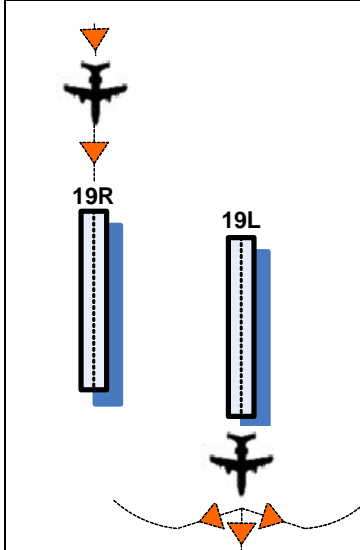
## 2. BANGKOK/SUVARNABHUMI INTERNATIONAL AIRPORT

### 2.1 Model 1 : Segregated parallel operation

#### a) Operational conditions

- 1) Runway 19L is used in departure operation.
- 2) Runway 19R is used in arrival operation.
- 3) Parallel runway separation is 2,200 m. (between 19L and 19R)
- 4) Airport Surveillance Radar (ASR), scan time 5 seconds.
- 5) Aircraft mix
  - i. Heavy 70%
  - ii. Medium 29%
  - iii. Light 1%
- 6) Approach speeds
  - i. Heavy 150 knots
  - ii. Medium 140 Knots
  - iii. Light 110 Knots
- 7) Common approach length 7 nm.
- 8) Intrail delivery error standard deviation is 18 seconds.
- 9) Large hub separation criteria. (3/4/5/6 nm)
- 10) VMC weather conditions.

#### b) Model and Runway capacity

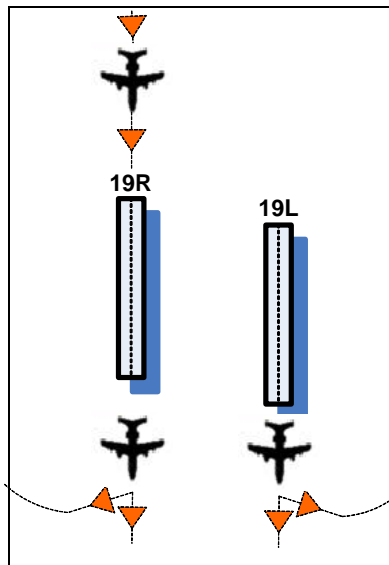
	Runway-in-use	Per hour	
		Arrival	Departure
Runway 19R		26.18	-
Runway 19L		-	39.82
<b>Total</b>		<b>66.0</b>	

**2.2 Model 2 : Semi-mixed operation**

a) Operational conditions

- 1) Runway 19L is used in departure operation.
- 2) Runway 19R is used in mixed operations mode.
- 3) Parallel runway separation is 2,200 m. (between 19R and 19L)
- 4) Airport Surveillance Radar (ASR), scan time 5 seconds.
- 5) Aircraft mix
  - i. Heavy 70%
  - ii. Medium 29%
  - iii. Light 1%
- 6) Approach speeds
  - 2.2.1 Heavy 150 knots
  - 2.2.2 Medium 140 Knots
  - 2.2.3 Light 110 Knots
- 7) Common approach length 7 nm.
- 8) Intrail delivery error standard deviation is 18 seconds.
- 9) Large hub separation criteria. (3/4/5/6 nm)
- 10) VMC weather conditions.

b) Model and Runway capacity

	Runway-in-use	Per hour	
		Arrival	Departure
Runway 19R		15.29	15.29
Runway 19L		-	39.82
<b>Total</b>		<b>70.40</b>	

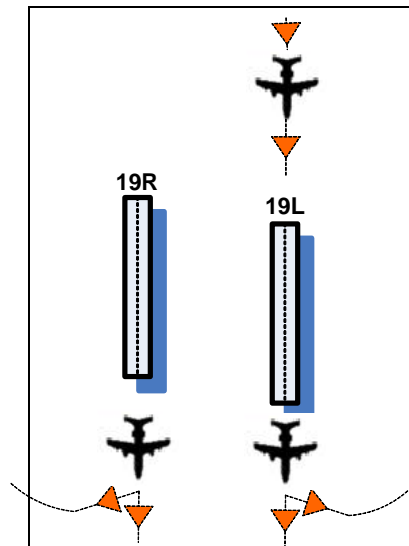
**2.3 Model 3 : Semi-mixed operation**

a) Operational conditions

- 1) Runway 19L is used in mixed operations mode.
- 2) Runway 19R is used in departure operation.
- 3) Parallel runway separation is 2,200 m. (between 19R and 19L)
- 4) Airport Surveillance Radar (ASR), scan time 5 seconds.
- 5) Aircraft mix
  - i. Heavy 70%
  - ii. Medium 29%
  - iii. Light 1%
- 6) Approach speeds
  - i. Heavy 150 knots
  - ii. Medium 140 Knots
  - iii. Light 110 Knots
- 7) Common approach length 7 nm.
- 8) Intrail delivery error standard deviation is 18 seconds.
- 9) Large hub separation criteria. (3/4/5/6 nm)
- 10) VMC weather conditions.

b) Model and Runway capacity

Runway-in-use	Per hour	
	Arrival	Departure
Runway 19R	-	39.82
Runway 19L	15.29	15.29
<b>Total</b>	<b>70.40</b>	



The diagram illustrates the layout of Runway 19R and Runway 19L. Runway 19R is on the left and Runway 19L is on the right. Aircraft icons are shown on both runways, with arrows indicating the direction of traffic. Approach paths are shown as dashed lines with orange triangles at the end, indicating the direction of arrival and departure. The runways are separated by a distance of 2,200 meters.

**2.4 Model 4 : Semi-mixed operation**

a) Operational conditions

- 1) Runway 19L is used in mixed operations mode.
- 2) Runway 19R is used in arrival operation.
- 3) Parallel runway separation is 2,200 m. (between 19R and 19L)
- 4) Airport Surveillance Radar (ASR), scan time 5 seconds.
- 5) Aircraft mix
  - i. Heavy 70%
  - ii. Medium 29%
  - iii. Light 1%
- 6) Approach speeds
  - i. Heavy 150 knots
  - ii. Medium 140 Knots
  - iii. Light 110 Knots
- 7) Common approach length 7 nm.
- 8) Intrail delivery error standard deviation is 18 seconds.
- 9) Large hub separation criteria. (3/4/5/6 nm)
- 10) VMC weather conditions.

b) Model and Runway capacity

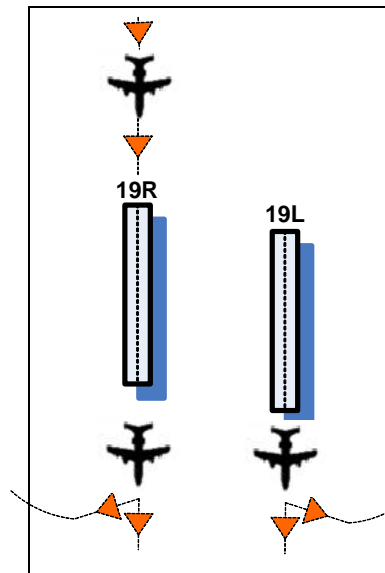
Runway-in-use	Per hour	
	Arrival	Departure
Runway 19R	26.18	-
Runway 19L	15.29	15.29
<b>Total</b>	<b>56.76</b>	

**2.5 Model 5 : Semi-mixed operation**

a) Operational conditions

- 1) Runway 19L is used in arrival operation.
- 2) Runway 19R is used in mixed operations mode.
- 3) Parallel runway separation is 2,200 m. (between 19R and 19L)
- 4) Airport Surveillance Radar (ASR), scan time 5 seconds.
- 5) Aircraft mix
  - I. Heavy 70%
  - II. Medium 29%
  - III. Light 1%
- 6) Approach speeds
  - I. Heavy 150 knots
  - II. Medium 140 Knots
  - III. Light 110 Knots
- 7) Common approach length 7 nm.
- 8) Intrail delivery error standard deviation is 18 seconds.
- 9) Large hub separation criteria. (3/4/5/6 nm)
- 10) VMC weather conditions.

b) Model and Runway capacity

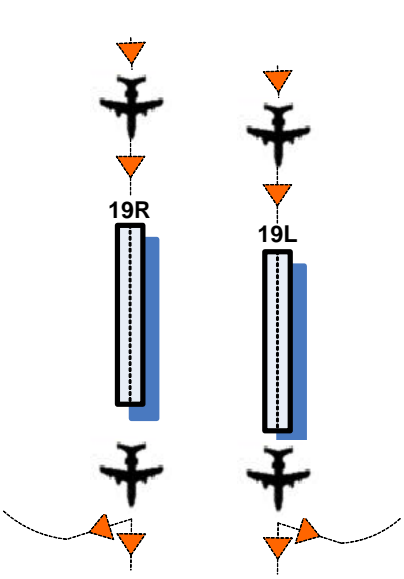
	Runway-in-use	Per hour	
		Arrival	Departure
Runway 19R		15.29	15.29
Runway 19L		26.18	-
<b>Total</b>		<b>56.76</b>	

**2.6 Model 6 : Mixed operation**

a) Operational conditions

- 1) Runway 19R and 19L are used in mixed operations mode.
- 2) Parallel runway separation is 2,200 m. (between 19R and 19L)
- 3) Airport Surveillance Radar (ASR), scan time 5 seconds.
- 4) Aircraft mix
  - i. Heavy 70%
  - ii. Medium 29%
  - iii. Light 1%
- 5) Approach speeds
  - i. Heavy 150 knots
  - ii. Medium 140 Knots
  - iii. Light 110 Knots
- 6) Common approach length 7 nm.
- 7) Intrail delivery error standard deviation is 18 seconds.
- 8) Large hub separation criteria. (3/4/5/6 nm)
- 9) VMC weather conditions.

b) Model and Runway capacity

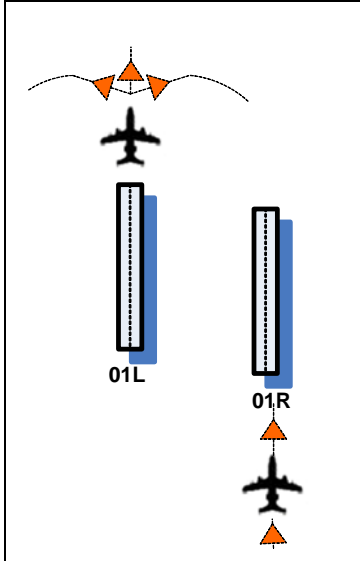
	Runway-in-use	Per hour	
		Arrival	Departure
Runway 19R		15.29	15.29
Runway 19L		15.29	15.29
<b>Total</b>		<b>61.16</b>	

**2.7 Model 7 : Segregated parallel operation**

a) Operational conditions

- 1) Runway 01L is used in departure operation.
- 2) Runway 01R is used in arrival operation.
- 3) Parallel runway separation is 2,200 m. (between 01L and 01R)
- 4) Airport Surveillance Radar (ASR), scan time 5 seconds.
- 5) Aircraft mix
  - i. Heavy 70%
  - ii. Medium 29%
  - iii. Light 1%
- 6) Approach speeds
  - i. Heavy 150 knots
  - ii. Medium 140 Knots
  - iii. Light 110 Knots
- 7) Common approach length 7 nm.
- 8) Intrail delivery error standard deviation is 18 seconds.
- 9) Large hub separation criteria. (3/4/5/6 nm)
- 10) VMC weather conditions.

b) Model and Runway capacity

	Runway-in-use	Per hour	
		Arrival	Departure
Runway 01L	-	-	39.82
Runway 01R	26.18	-	-
<b>Total</b>		<b>66.0</b>	

2.8 Arrival and Departure Diagram

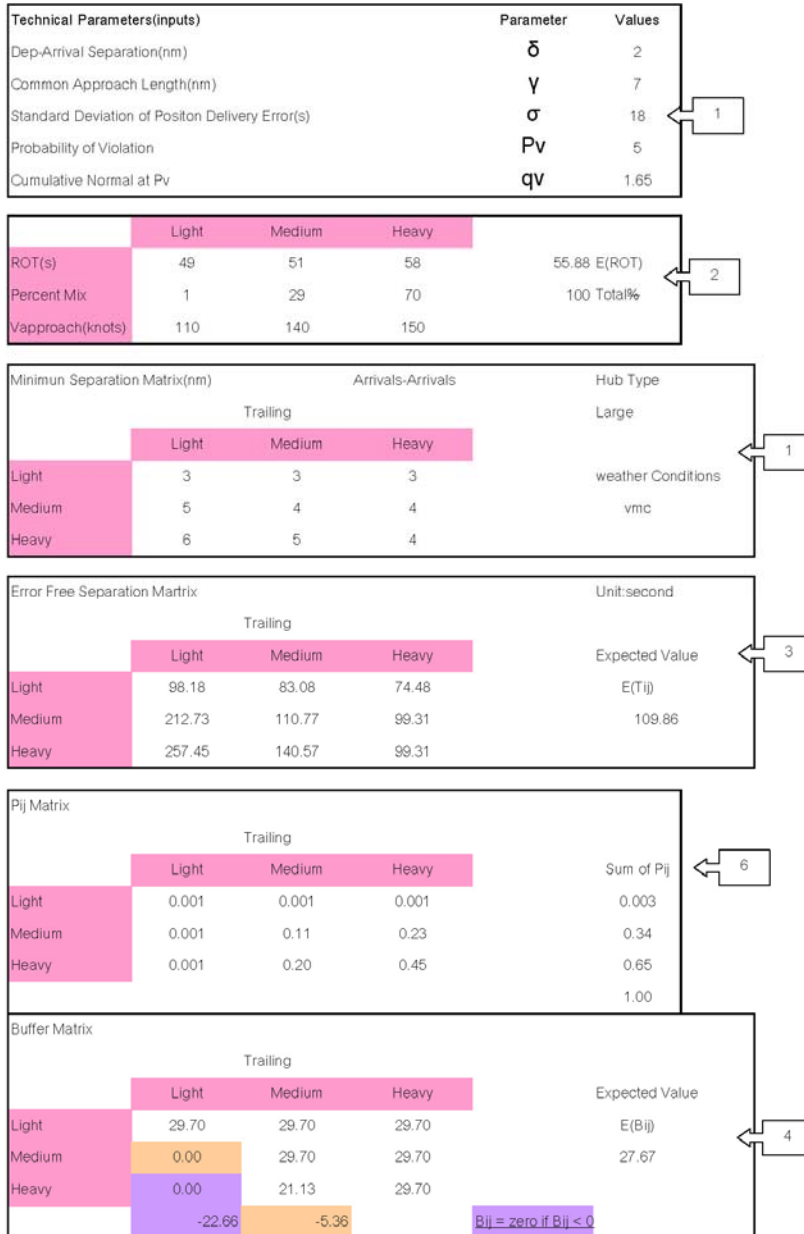
ARRIVAL - DEPARTURE DIAGRAM.  
VMC CONDITION



2.9 The estimation, in the event of VMC condition

Runway Separation Capacity Estimation

ในกรณีสภาพอากาศ VMC



		Trailing			Expected Value $E(T_{ij}) + E(B_{ij})$
		Light	Medium	Heavy	
Light		127.88	112.78	104.18	137.53
Medium		212.73	140.47	129.01	
Heavy		257.45	161.70	129.01	

Arrivals Only Capacity(per hour) 26.18

Departure-Departure Separation Matrix(nm) unit:second

		Trailing		
		Light	Medium	Heavy
Light		60	90	120
Medium		90	90	90
Heavy		120	90	90

Expected Value $E(T_d)$	
90.417	90.417

Departures Only Capacity(per hour) 39.82

Estimation of Critical Departure Gaps

Departures	Gap( $E \Delta T_{ij}$ )	$E(ROT)$	$E(\delta/v_j)$	$\sigma g^* q v$	$E(\Delta T_{ij})$
1	144.98	55.88	59.40	29.70	144.98
2	235.40				
3	325.81				
4	416.23				
5	506.65				

50% ARRIVALS + 50% DEPARTURES	
Departures Capacity(per hour)	15.29
Arrivals Capacity(per hour)	15.29

Summary for Arrival - Departure Diagram

Arrival	Departures	Operation Pattern
26.18		Arrivals Only
15.29	15.29	50 % Arrivals + 50 % Departures
	39.82	Departures Only