Civil and Enviromental Engineering, Gadjah Mada University

PUBLIC TRANSPORT PLANNING
(Frequency, Headway, and Number of Bus)

Introduction of Transport Planning

Dr.Eng. Muhammad Zudhy Irawan, S.T., M.T.

Frequency and Headway

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INTRODUCTION

- Frequency and headway is influenced by:
    1. Number of passengers
    2. Bus capacity
    3. Minimum Frequency allowed

- Headway = 1 / Frequency

- In Urban area, headway of public transport is as follows:
    - 5 – 10 minute during peak hour
    - 10 - 20 minute during no peak hour

METHOD FOR THE CALCULATING OF FREQUENCY

- There are 3 methods for the calculating of frequency:
    1. Based on the maximum passengers per day
    2. Based on the maximum passengers per hour
    3. Based on passengers - km

- Based on the maximum passengers per hour is a method that often used in Indonesia

- Determine the frequency with Method 1 and 2

$$F_{metode-1} = \max\left[\frac{P_{hari-tersibuk}}{d}, F_{\min}\right] \quad F_{metode-2} = \max\left[\frac{P_{jam-tersibuk}}{d}, F_{\min}\right]$$

F   : Frequency

P   : Number of passengers

d   : Number of bus capacity

     Example

     Bus Capacity (c) = 85 (35 sit and 50 stand)

     Bus should be filled with load factor 80% for comfortable,

     then value of d = 0,8 x 85 = 68 passengers

$F_{\min}$: Minumum frequency

- Determine the frequency with Method 3

$$F_{metode-3} = \max\left[\frac{A}{d.L}, \frac{P_{jam-tersibuk}}{c}, F_{\min}\right]$$

F   : Frequency

A   : Number of passengers-km in 1 route

L   : Route length

Example 1

- The bus operates from 6-11 PM with the number of passengers as follow:

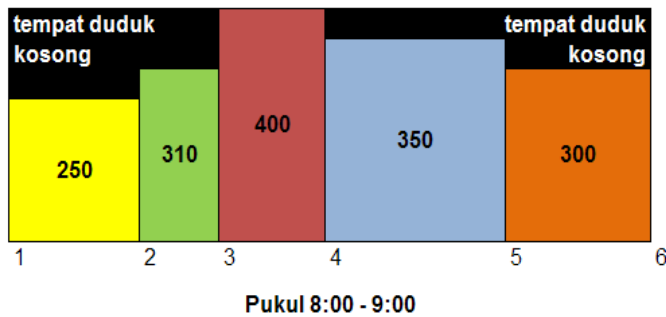| Bus stop	Distance between bus stop	Number of Passengers					Pnp Total
		6 – 7	7 – 8	8 – 9	9 – 10	10 – 11	
1	2	50	136	245	250	95	776
2	1	100	**510**	310	208	122	1250
3	1,5	**400**	420	**400**	**320**	200	**1740**
4	3	135	335	350	166	**220**	1206
5	2,5	32	210	300	78	105	725

- Route length = 10 km
- d = 50 passengers, c = 90 passengers
- F_{min} = 3 times/hour

- Question: Calculate the frequency of bus and the headway with method 1,2,3!

Period	Method 1		Method 2	
	Frequency	Headway	Frequency	Headway
6 – 7	Max (400/50;3) = 8	60/8 = 7,5	Max (400/50;3) = 8	7,5
7 – 8	Max (420/50;3) = 8,4	7	Max (510/50;3) = 10,2	6
8 – 9	Max (400/50;3) = 8	7,5	Max (400/50;3) = 8	7,5
9 – 10	Max (320/50;3) = 6,4	9	Max (320/50;3) = 6,4	9
10 - 11	Max (200/50;3) = 4	15	Max (220/50;3) = 4,4	14

Period	Method 3	
	Frequency	Headway
6 – 7	Max (1285/50.10 ; 400/90 ; 3) = 4,44	14
7 – 8	Max (2942/50.10 ; 510/90 ; 3) = 5,88	10
8 – 9	Max (3200/50.10 ; 400/90 ; 3) = 6,4	9
9 – 10	Max (1881/50.10 ; 320/90 ; 3) = 3,72	16
10 - 11	Max (1534/50.10 ; 220/90 ; 3) = 3,07	20

- Passengers-km on period 6-7

  = (2 x 50) + (1 x 100) + (1,5 x 400) + (3 x 135) + (2,5 x 32) = 1285 pnp - km

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Example: in case at 08.00-09.00 with method 1 and 2

Pukul 8:00 - 9:00

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With method 3 at 8:00-09:00

- Passenger are not transported, it could be transported in the next hour
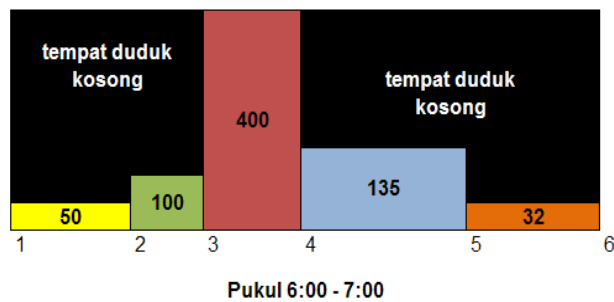- Watch the demand in the next hour,, is it possible?

Fewer empty chairs

Pukul 8:00 - 9:00
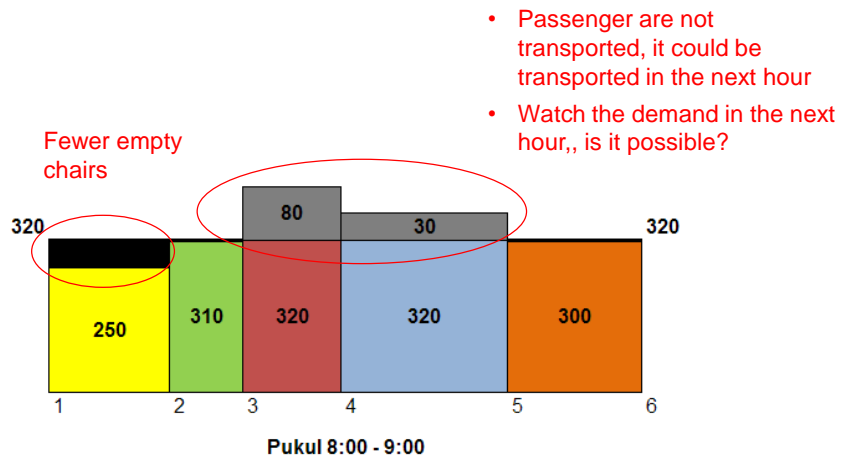
Task

- What would you consider to that case at 06:00 – 07:00 with method 1 and 2?

- Compare with method 3 !

Pukul 6:00 - 7:00

Task

- Determine the bus frequency at 6-7, 7-8, ….., 10-11 which minimizes the number of empty chairs

  Note:

  1. Consider the number of passengers which could not be transported if there is a frequency optimalization
  2. Consider the reduce of comfortable for frequency optimilization
  3. Consider to minimizes the change of frequency in each hour to make the passengers are not confused

Number of Bus

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- The number of bus is not same as the frequency

- The number of bus is influenced by:
    1. Frequency and headway
    2. Route travel time (average and rerata dan standard deviation), break time in bus stationwaktu istirahat di terminal

- example:
    - Route A is circular route with total circulation time = 15 minute
    - At 06.00-07.00 in route A, it is needed a public transportation with headway = 6 minute
    - Question:
    - A. Bus frequency?
    - B. Number of Bus?

- Frequency:

  F = 1/6 x 60 minute = 10 bus

- Number of bus = 3 bus

No	depart	arrive	Bus -
1	06:00	06:15	1
2	06:06	06:21	2
3	06:12	06:27	3
4	06:18	06:33	1
5	06:24	06:39	2
6	06:30	06:45	3
7	06:36	06:51	1
8	06:42	06:57	2
9	06:48	07:03	3
10	06:54	07:09	1

- Number of bus is calculated by divided the total circulation time with headway

- Total circulation time is calculated as follows:

$$CT_{ABA} = (T_{AB} + T_{BA}) + (\delta_{AB}{}^2 + \delta_{BA}{}^2) + (T_{TA} + T_{TB})$$

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PUBLIC TRANSPORT PLANNING
(*Financing*)

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EXPENSE FOR ROAD BASED TRANSIT

- For the cost of procurement:
    1. bus cost is 300.000- 330.000 USD
    2. 450.000 - 500.000 USD for *articulated bus*

- For the cost of ROW
    1. Close to Rp. 0 if it use existing road
    2. If use special lanes, that is based on land acquisition, road construction, etc.
- Example: in early development, BRT in Beijing needs $4.75 million, Hangzhou's BRT system needs $19 to 25 million for 28 km then TransJakarta needs $10 million

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- For operational cost:
    1. Direct cost (fuel, salary, etc)
    2. Maintenance cost
    3. Administration cost
    4. marketing and advertising cost
    5. Tax
    6. Insurance

- Direct cost are the biggest of expense, it reaches about 45-60% from total operational cost

EXPENSE FOR RAIL BASED TRANSIT

- For early cost
    1. $10 – 30 million/km for *Light Rapid Transit* (LRT),
    2. $60 - 100 million/km for *Heavy Rapid Transit*/Metro
   3. $1 - 4 million/km for train which is build on *existing* ROW

- For maintenance and procurement cost
    1. Operational cost (employee salary, Guard station, supervisor monitor, etc)
    2. Fuel cost (based on fuel types which is used)
    3. Maintenance cost (worker, repair, testing, cleaning, etc)

4. *Permanent-way maintenance (tracks, power supply, signals*, dll.)
5. *General and administration,* berupa *indirect operating costs* (*management, legal services, accounting, insurance, employee benefits, maintenance of building and grounds*)

INCOME

Intrumen Pendapatan Umum	Intrumen Pendapatan Langsung	Instrumen Pendapatan Tidak Langsung
• Subsidi angkutan umum • Pajak property • Pinjaman dan hibah nasional dan internasional • Instrumen finansial yang berkaitan dengan perubahan iklim • Global Environmental Facility (GEF) • Clean Technology Fund • Clean Development Mechanism (CDM) • Public-Private Partnerships (PPs) untuk angkutan umum	• Biaya Parkir • Jalan Berbayar • Biaya kemacetan • Pajak bahan bakar dan biaya tambahan • Pajak kendaraan • Pendapatan *fare box* • PPPs untuk jalan perkotaan	• Iklan • Kontribusi pegawai • Pendapatan dari peningkatan Nilai tanah dan property • Pajak nilai tanah • Pembiayaan kenaikan pajak (TIF) • Penilaian Khusus • Biaya pemanfaatan Transportasi • Pengelolaan aset tanah • Pungutan yang ditanggung pengembang (*exactions*) • Biaya dampak pembangunan • Pungutan yang dapat dirundingkan • *Joint developments* • Hak atas udara

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Penggunaan instrumen finansial ke dalam tiga kategori: Modal, Operasional, dan Pemeliharaan
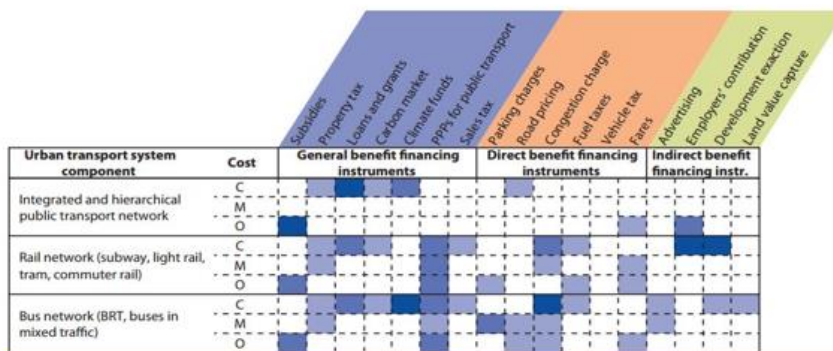
Catatan: C=Modal; M=Pemeliharaan; O=Operasional; Semakin gelap warna pada kotak darker, semakin banyak instrumen yang digunakan untuk tujuan pada contoh.