Performance Study of Three Parallel Runways at Soekarno-Hatta Airport

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Abstract— To improve service quality, Soekarno-Hatta international airport is adding a runway, so that the runway becomes a three-parallel runway. The runway is targeted to be able to accommodate the number of aircraft movements until 2020. This final assignment tries to find out whether the capacity of the planned runway can meet the targets that have been set. In this final project, we will review the distribution pattern of aircraft categories and the distribution of aircraft departure/arrival movements that affect the runway, then a simulation of aircraft movements will be carried out to obtain capacity on the runway. From the final assignment, the percentage distribution results of the aircraft categories used were C: 45% and D: 55%. The distribution of aircraft movements for runway 1 is departure: 59% and arrival: 41%, for runway 2 it is departure: 32.5% and arrival: 67.5% while for runway 3 it is departure: 40% and arrival: 60%. The results of the simulation of movements at peak hour were 124 movements. It is known from the data that peak hour aircraft movements in 2020 were 148 movements. With the results obtained, it was concluded that the aircraft movement target could not be met by adding the runway to a three-parallel runway.

Keywords— Aircraft, runways, Movement Aircraft, Simulation.

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I. INTRODUCTION

Aircraft is one of the means transportations Which Lots used moment This, specifically for country Indonesia Which is a country Island Where transportation air very role important for smoothness activity its inhabitants. Body Center Statistics (CPM) take notes amount passenger air in a number Airport in Indonesia on year 2014 reach 72.6 million people, go on 5,6 percent from year 2013 as much 68.5 million persons. Moment This, in airport international Soekarno-Hatta scheduled around 1,200 flight every day. Amount flight the set airport Soekarno-Hatta as airport busiest in Indonesia as well as enter to in list 10 airport busiest in world.

Every year there is a corresponding increase in aircraft movements with its height growth amount passenger transportation air result happen delay (delay) long either for the plane that is about to land or the plane that is will free take off. Matter This Because, airport as place walking activity transportation air own amount capacity service Which limited and different every airport. This increase in passenger growth if not accompanied by additional capacity airport will causing excess capacity capacity).

At the beginning of construction, airport international Soekarno-Hatta has two parallel runways separated by 2 taxiways for 2.4 km. To increase capacity, take off spur airport, so planned additional runway. Runway construction is divided into 2 stages, with each stage adding 1 runway so that amount runways Which There is in Airport Soekarno-Hatta became 4 runways [1]. This final assignment will be discussing development stage 1 Which will held on in 2015 and is estimated to be completed in 2017. The end of phase 1 development is the runway which operates on airport Soekarno-Hatta become runways with type three parallel. In

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this final assignment, a simulation will be carried out will give description capacity runways from third parallel runways the. are runways Can accommodate Capacity growth is expected to occur in 2020. In figure 1.3 it can be seen runways 1, 2 and 3. Third parallel runways These three parallel runways will be simulated to determine the capacity of the three runways.

The aim of this final assignment is to evaluate the number aircraft movements that can be accommodated by the third runways on year 2020, And explained under This:
1. Identify characteristics pattern operational runways existing.
2. Know the amount of movement aircraft existing based on flight schedules at Soekarno airport Hatta.
3. Knowing the number of aircraft movement capacities capable of accommodate by runways Which available on year 2020.

II. METHOD

The research flow diagram is displayed in Figure 2.

III. RESULTS AND DISCUSSION

A. Determination Peak hour

In calculating the capacity of the existing runway, data is needed airport peak hours will be calculated. Peak hour is the hour busiest it gets on busiest month of the year [2]. Data Which will used is data timetable flight airport international Soekarno-Hatta. Based on the data, it is known that the largest number of flights exists on Wednesday 15 July 2015 with total movement aircraft a number 1267 movement per day. So peak hour There is on date 15 July 2015. On picture 3, can see results from recapitulation calculation peak hour biggest on day Wednesday date 15 July 2015 in airport international Soekarno-Hatta. peak hours are obtained hour) occurred at 12:45 PM – 1:44 PM for a total of 94 movement aircraft.

B. Time Method Existing Runway Capacity Calculation Space Analysis

Time space analysis is a simple method that used to calculate runway capacity If headway between aircraft is known. For

Fig 1. Airport layout the new Soekarno-Hatta

Fig 2. Diagram Flow Study

count capacity something runways there are several rule operations Which must fulfilled runways in the workmanship. Rule – rule sorting base Which used in sorting aircraft fly [3] is:

1. Two aircraft fly No can operate in *runways* on moment Which simultaneously.
2. Aircraft Which come given priority for use *runways* from on aircraft which leave.
3. Departure operations can be carried out on *the runway* has been released and the next arrival is the least is at on something distance certain from threshold *runways.*

Calculation capacity method time space analysis use timetable arrival and departure based on peak hour data at Soekarno-Hatta airport on day Wednesday July 15, 2015. It is assumed that runway 1 serves movement for terminal 1 And runways 2 serve move for terminals 2 and 3. The following is the distribution of aircraft movements at runways 1 And 2 shown on table 1.

1. Method Mathematical

In the mathematical method, capacity calculations are carried out for category arrival just (Arrival only), departure just (Departure only) And operation mixture (Mixed operations). Results from calculating the existing capacity of runway 1 and runways 2 can see on picture 4 And picture 5.

2. Calculation Simulation

Calculations are made for the mixed operating capacity. There are 44 flight schedules that must be served by runway 1 and 50 flight schedules that must be served runways 2.

Furthermore, with use program help Microsoft Excel done steps as following:

a. Determine matrix distance separator minimum *arrival-arrival* for each category aircraft, *Heavy* followed by *Heavy, Heavy* followed by *Large* And so on.
b. Get the inter-arrival time by means share distance separator minimum between aircraft with speed each aircraft.
c. Get time arrival / departure (Time *of Arrivals / departure)* aircraft Which is the accumulation of inter-arrival times aircraft.
d. Determine ROT (Runway Occupancy Time) by dividing the required length of the runway runways with speed each aircraft.
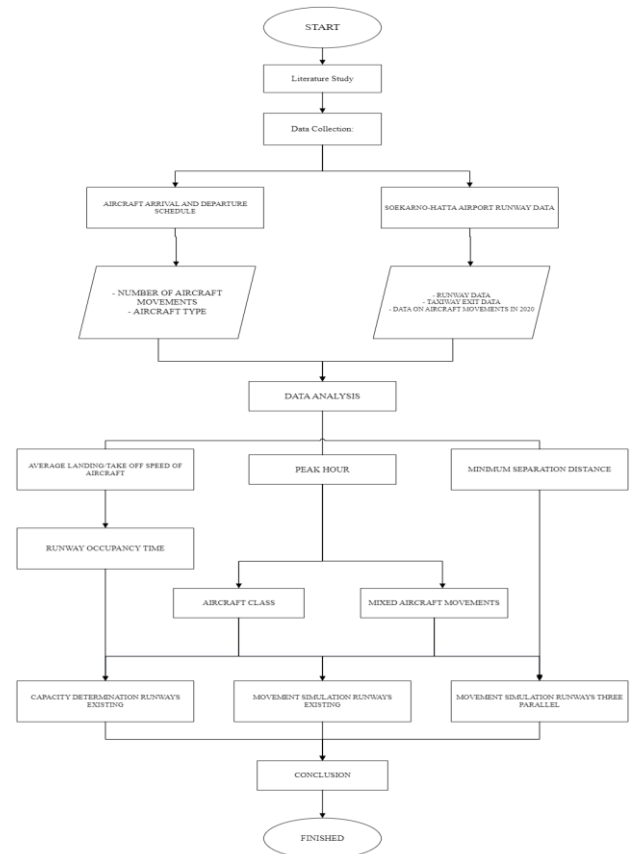e. With add up time arrival with long time usage runways average (ROT) so will obtain time end, that is time when

aircraft has land and go out from runways. after That will be added up and accumulated until with time not enough from / equals 60 minutes and you will get the amount movement aircraft.

Examples of calculations carried out to obtain capacity *runways* is as follows:

a) Determine separator minimum.

Minimum separation distance between aircraft for operations mixture is almost with calculation previously, for arrival-arrival is separation arrival-arrival shared with speed aircraft landing, for departure-departure is the same as the distance separator minimum between aircraft for departure-departure, for arrival-departure is the same with a minimum separation distance between aircraft for departure-departure, whereas minimum separator minimum for departure-arrival is 2nmi. Following recap separator minimum for calculation runways existing Which shown on table 2.

i. Arrivals – arrival

If aircraft in front of including category C with speed plane as big as 132 knots and aircraft behind including category D, so:

Interarrival time = (3/132) x (3600)

= 81.82 second = 1.36 minute

ii. Departure – departure

Interarrival between departure-departure the same with the minimum separation, so that if the plane is in front including category D and the aircraft behind including category D then:
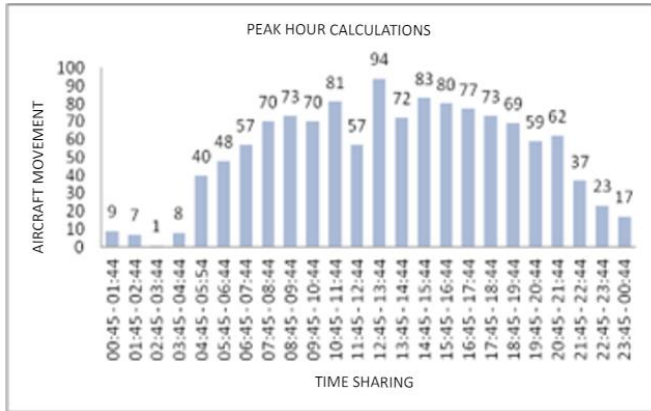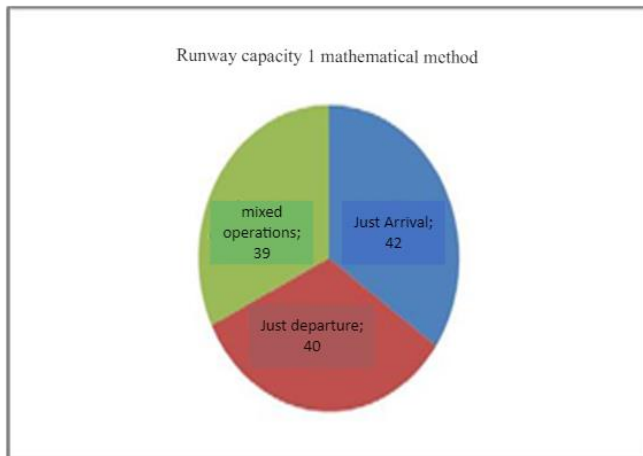
Fig 3. Calculation peak hour
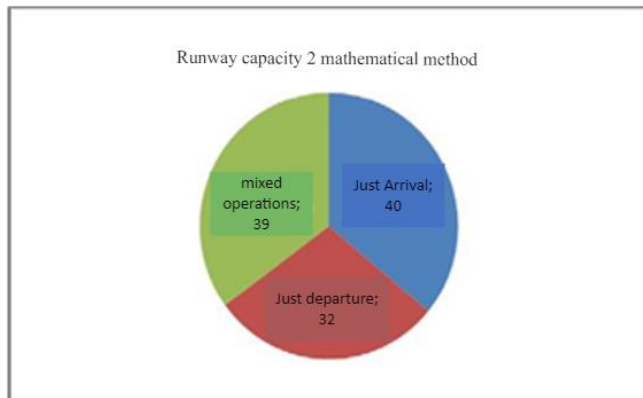

Fig 4. Runway capacity 1

Fig 5. Runway capacity 2

Interarrival time = 120 second = 2 minutes
iii. Arrivals – departure

Interarrival between arrival-departure the same with the minimum separation, so that if the plane is in front including category C and the aircraft behind including category D, so:

Interarrival time = 90 second = 1.5 minutes
iv. Departure – arrival

If aircraft in front of including category C with speed plane as big as 139 knots and aircraft behind including category C, so:

TABLE 1.
Distribution runway movement 1 And 2

	Total	Arrivals	Departure	Arrivals (%)	Departure (%)
Runways 1	44	18	26	41	59
Runways 2	50	33	17	66	34

TABLE 2.
Recap separator minimum between aircraft

Leading	Trailing			
	C (Arrival)	D (Arrival)	C (Departure)	D (Departure)
	nm	nm	second	second
C (Arrival)	3	3	60	90
D (Arrival)	5	3	120	120
C (Departure)	2	2	60	90
D (Departure)	2	2	120	120

Interarrival time = (2/139) x (3600)
= 51.80 second = 0.86 minute

b) Time arrival/departure (Time *of Arrival/departure*)

Is accumulation from interarrival time. Example calculation time of arrival / departure:

Time of arrival   = 1.36+ 2.0
= 3.36 minutes

Time of arrival   = 3.36 +1.50
= 4.86 minutes

c) ROT (Runway *Occupancy Time*)

Got it from distribution between long base and the speed of each category of aircraft taken from aircraft data.

d) Time end (Time Service Ends)

Is amount from time of arrival with ROT.

Time service ends   = 1.36 + 0.39
= 1.75 minute

Accumulated so on until the movement of the aircraft final. The amount of capacity movement of the aircraft calculated is less than / equal to 60 minutes. results calculation can be seen in picture 6.

Based on calculation capacity runways exiting use t time space analysis with method mathematical and use program help Microsoft Excel, obtained comparison amount movement aircraft for operation mixture (mixed) between second method as following picture 7. 3.

3. Control Simulation

To better understand the principles of movement simulation aircraft on runway, so done depiction movement aircraft in diagram time and distance (Time-space diagrams). Depiction This based on runway aircraft movements during peak hours and only taken part just.

C. Forecasting peak hour on year 2020

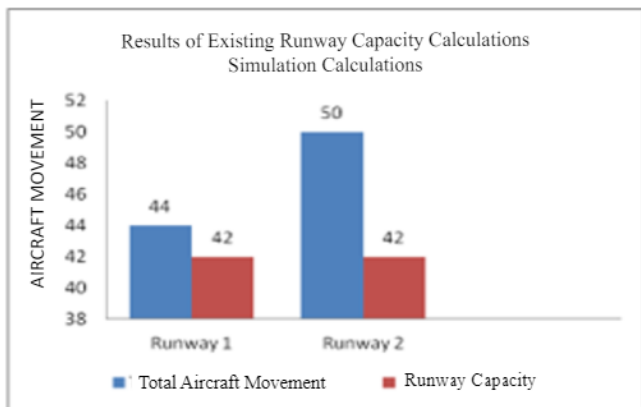To find the target peak hour in 2020 then moreover formerly

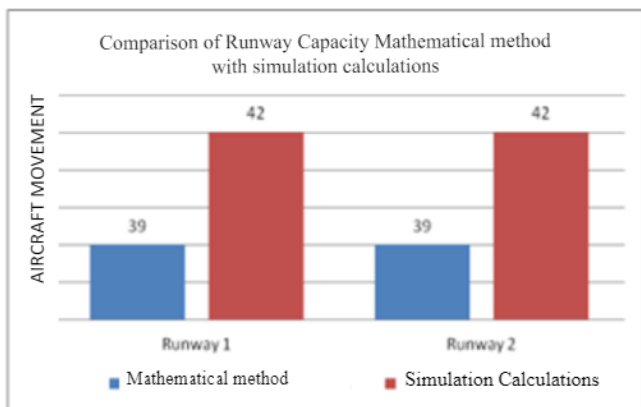Fig 6. Capacity exiting runways use program Microsoft Excel

Fig 7. Comparison capacity method mathematical with calculation simulation

Fig 8. Time space runway diagram 1

Fig 9. Time space runway diagram 2

look for movement per day. From data It is known that the growth of aircraft movements in 2020 is as big as 729,886 movement/year. So that obtained:

Movement per day year 2020 = $\frac{729,886}{365}$

= 1,999.7

= 2000 Movement/day

From amount movement per day year 2020 Which found, then will searching for amount movement on peak hour. Calculation done with method multiply percent movement per clock on Wednesday July 15th, 2015, with amount movement per day year 2020.

Chart Which will show enhancement and decline percentage of aircraft movements on July 15, 2015, that can see on picture 10.

Based on the graph on July 15, 2015, it is known movement in the hours 00:45 – 01:44 amounted to 0.71% of the total 1267 moves. Then from these calculations it is taken the hour that produces the greatest amount of movement. Look at table 6.

Based on picture 11 obtained amount movement biggest is at 12:45 PM – 1:44 PM with a total of 148 aircraft movement. So, the peak hour in 2020 is 148 movement.

D. Simulation Runway Year 2020

On basically calculation Which done the same with calculation capacity runways existing with method time space analysis using the Microsoft Excel program like calculation
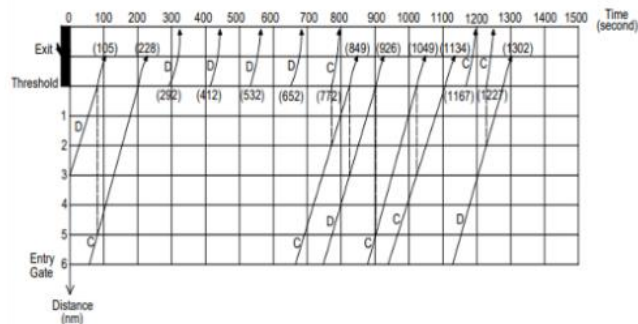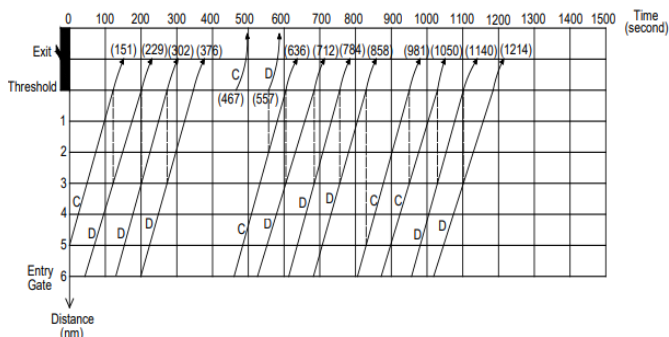
before This. Calculation simulation the runway capacity used is operational mixture (mixed). Aircraft speed and aircraft ROT are taken from average value of aircraft movements at peak hour on the 15th of July 2015, that can see on table 3 under.

The percentage division of aircraft categories is obtained based on peak hour on July 15, 2015, which can be seen on table 4.

Whereas For percentage arrival and departure every runway shared based on use terminal. Runways 1 used for terminal, runways 2 used for terminal 2 and runway 3 for terminal three. Following percentage of arrivals and departures for calculation simulation runways Which showed on table 5.

Minimum separation distance for arrival/departure Can seen on table 2 Recap separator minimum between aircraft.

Calculation simulation This will execute use program help Microsoft Excel with step- step as follows:

1. Determine timetable arrival each category plane using a random number formula there is on auxiliary program Microsoft Excel. Percentage Existing aircraft categories are made equal to the percentage category aircraft on runways on airport Soekarno-Hatta.

2. arrival-arrival minimum separation distance matrix for each category aircraft, Heavy followed Heavy, Heavy is followed by Large and so on. With distance units is nautical miles (nmi) or second.

3. Determine approaches speed each category aircraft with refers on data timetable arrival airport Soekarno-Hatta. Approach speed each the aircraft category used is the average value of movement peak time hour.

4. Get the inter-arrival time by dividing distance between

TABLE 3.

Speed and ROT average aircraft

Type Aircraft	speed landing (knots)	Speed take off (Knots)	ROT	
			Arrivals	Departure
C	135	143	0.35	0.45
D	149	148	0.36	0.51

TABLE 4.

Distribution Category Aircraft

Category Aircraft	Amount Movement	Percentage (%)
C	42	45
D	52	55
Total	94	100

TABLE 5.

Percentage Arrival/Departure for Every Runways

Arrival/ departure	Total		Percentage (%)	
	Arrivals	Departure	Arrivals	Departure
Terminal 1	18	26	41	59
Terminal 2	27	13	67.5	32.5
Terminal 3	6	4	60	40

category aircraft with speed each aircraft category.

5. After getting the inter-arrival time, you will get it aircraft arrival time from accumulated arrival times between planes.

6. Determine ROT (Runway Occupancy Time) by sharing long base runways with speed each category aircraft Which obtained from data class aircraft. From each aircraft category a value is taken average from category aircraft moment peak hour.

7. With add up time arrival with long the average runway usage time will be obtained end time, namely the time when the plane has landed and goes out from runways. after That will be added up and accumulated until with time not enough from / The same with 60 minutes and will get the number of aircraft movements per hour.

The following are the results of the 2020 runway simulation calculations, shown in figure 12.

Based on the sum of simulation calculations capacity of three runways parallel 2020, then you get it the result is 40 + 43 + 41 = 124 aircraft movements per hour for third runways Which the.

Results calculation capacity for year 2015 And 2020 can be seen in figure 13.

IV. CONCLUSION

This final assignment aims to get the number movement aircraft Which Can served by runways three parallel in airport
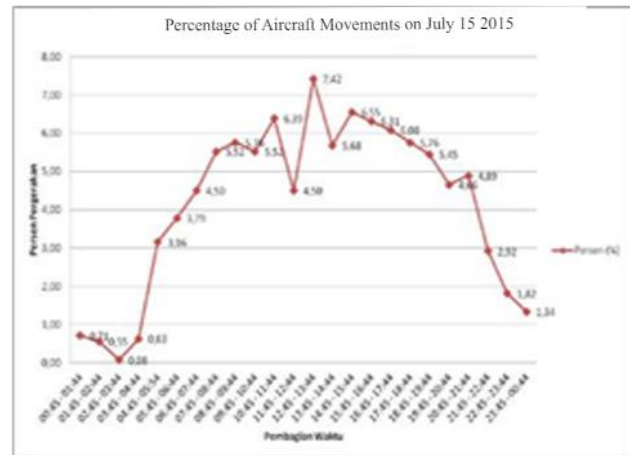

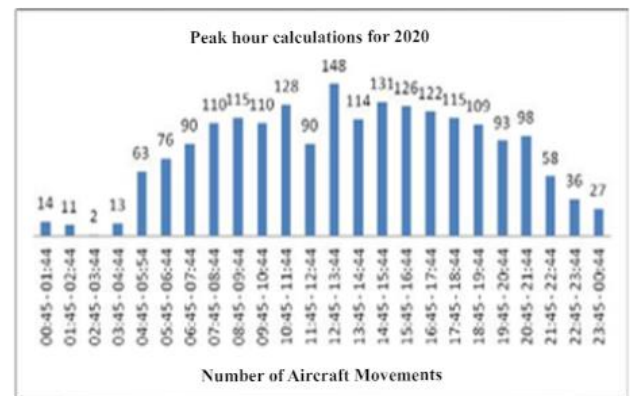Fig 10. Chart amount movement per hour on date 15 July 2015

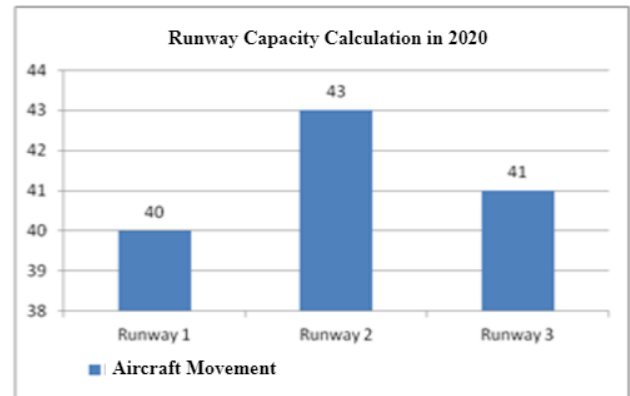Fig 11. Amount distribution movement per hour year 2020

Fig 12. Results simulation movement per O'clock year 2020

Soekarno-Hatta on year 2020.

From the results of the calculation analysis in this final project, can concluded several matters as following:

1. Characteristics pattern operational runways existing:
   a. Based on arrival and departure schedules on peak hour is known percentage composition category the aircraft used is C: 45% and D: 55%
   b. Comparison of arrival and departure percentages on runways 1 is arrival as big as 41% And departure as big as 59%.
   c. Comparison of arrival and departure percentages on runways 2 is arrival as big as 66% And departure as big
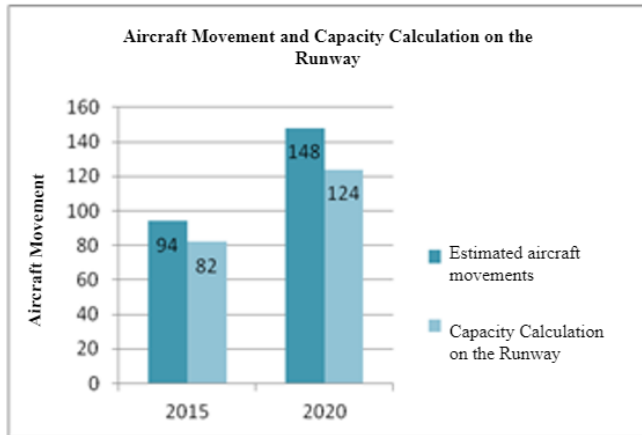
Fig 13. Comparison movement aircraft and its capacity

as 34%.

2. Calculation mathematical for capacity runways existing:
   a. Calculation use method mathematical:
      1) Runways 1

         For arrival just (arrival only) obtained runway capacity of 42 movements per hour, for arrival only (departure only) is obtained runway capacity of 40 movements per hour and for operation mixture (mixed) obtained capacity runways as big as 39 movement per O'clock.
      2) Runways 2

         For arrival just (arrival only) obtained runway capacity of 40 movements per hour, for arrival only (departure only) is obtained runway capacity of 32 movements per hour and for operation mixture (mixed) obtained capacity runways as big as 39 movement per O'clock.
   b. Calculation use Microsoft excel for capacity existing:
      1) Runways 1

         Runway 1 capacity is carried out using mixed operations obtained 42 movements per hour.
      2) Runways 2

         Runway 2 capacity is carried out using mixed operations obtained 42 movements per hour.

The result of the sum of 2 parallel runway movements Existing obtained a mixed movement of 84 movements aircraft per O'clock.

3. Simulation calculation of runway capacity for three parallel years 2020:
   a. Runways 1

      Simulation capacity runways 1 with distribution departure 59% And 41% arrival was obtained results by 40 movement per O'clock.
   b. Runways 2

      Simulation capacity runways 2 with distribution departure 32.5% And arrival 67.5% obtained results amounting to 43 movements per hour.
   c. Runways 3

      Simulation capacity runways 2 with distribution departure 40% And 60% arrival was obtained results by 41 movement per O'clock.

Results from summation movement runways three parallel obtained movement mixture (mixed) as big as 124 movement aircraft.

So that from statement on is known happen lateness, Which Can seen as following:
   a. On condition existing year 2015:

      Peak hour Which obtained for condition existing as big as 94 movement, whereas on calculation simulation method time space analysis movement Which Can served by 84 movements per hour. So, it's known there is lateness (delay) as much 10 movement.
   b. Estimation Condition on year 2020:

      Estimation Peak hour Which obtained for year 2020 as big as 148 movement, whereas on calculation

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