

## CHAPTER V

### RESULTS AND DISCUSSION



#### 5.1 Results

##### 5.1.1 Initial results

The developed program is run by using bus capacity of 50 persons and control time of 120 minutes. It results in 7 bus routes to pick up passengers from all 65 pick up points of current system as shown in Figure 5.1 and Table 5.1.

The screenshot shows a software window titled "Calculate Root" with the following parameters and results:

| No.        | Root Path                               | Time Use | Capacity | Saving |
|------------|-----------------------------------------|----------|----------|--------|
| 1          | 1,28,27,40,41,42,43,44,45,1             | 102.85   | 50       | 407.00 |
| 2          | 1,14,15,16,17,18,19,20,21,22,23,24,1    | 57.01    | 50       | 358.16 |
| 3          | 1,47,39,38,29,30,31,32,33,34,35,36,25,1 | 78.41    | 50       | 352.40 |
| 4          | 1,60,59,61,62,63,64,65,51,46,48,1       | 79.27    | 50       | 299.34 |
| 5          | 1,2,3,4,5,6,7,56,55,1                   | 51.53    | 50       | 147.32 |
| 6          | 1,52,50,49,66,10,11,13,12,26,37,1       | 51.07    | 50       | 170.14 |
| 7          | 1,53,54,57,58,8,9,1                     | 38.17    | 23       | 43.10  |
| Total time |                                         | 458.33   |          |        |

Figure 5.1 Bus routes with bus capacity of 50 persons and control time of 120 minutes

**Table 5.1** The results of design route

| <b>Route</b>                                                                   | <b>Total<br/>Pick up<br/>point</b> | <b>Passengers</b> | <b>Travelled<br/>Distance<br/>(km)</b> | <b>Time use<br/>(min)</b> |
|--------------------------------------------------------------------------------|------------------------------------|-------------------|----------------------------------------|---------------------------|
| <b>A:</b> 1 → 28 → 27 → 40 → 41 → 42 → 43<br>→ 44 → 45 → 1                     | 8                                  | 50                | 47.26                                  | 102.85                    |
| <b>B:</b> 1 → 14 → 15 → 16 → 17 → 18 → 19<br>→ 20 → 21 → 22 → 23 → 24 → 1      | 11                                 | 50                | 24.34                                  | 57.01                     |
| <b>C:</b> 1 → 47 → 39 → 38 → 29 → 30 → 31<br>→ 32 → 33 → 34 → 35 → 36 → 25 → 1 | 12                                 | 50                | 35.04                                  | 78.41                     |
| <b>D:</b> 1 → 60 → 59 → 61 → 62 → 63 → 64<br>→ 65 → 51 → 46 → 48 → 1           | 10                                 | 50                | 35.47                                  | 79.27                     |
| <b>E:</b> 1 → 2 → 3 → 4 → 5 → 6 → 7 → 56<br>→ 55 → 1                           | 8                                  | 50                | 21.60                                  | 51.53                     |
| <b>F:</b> 1 → 52 → 50 → 49 → 66 → 10 → 11<br>→ 13 → 12 → 26 → 37 → 1           | 10                                 | 50                | 21.37                                  | 51.07                     |
| <b>G:</b> 1 → 53 → 54 → 57 → 58 → 8 → 9 →<br>1                                 | 6                                  | 23                | 17.17                                  | 38.17                     |
| <b>Total</b>                                                                   | <b>65</b>                          | <b>323</b>        | <b>202.25</b>                          | <b>458.33</b>             |

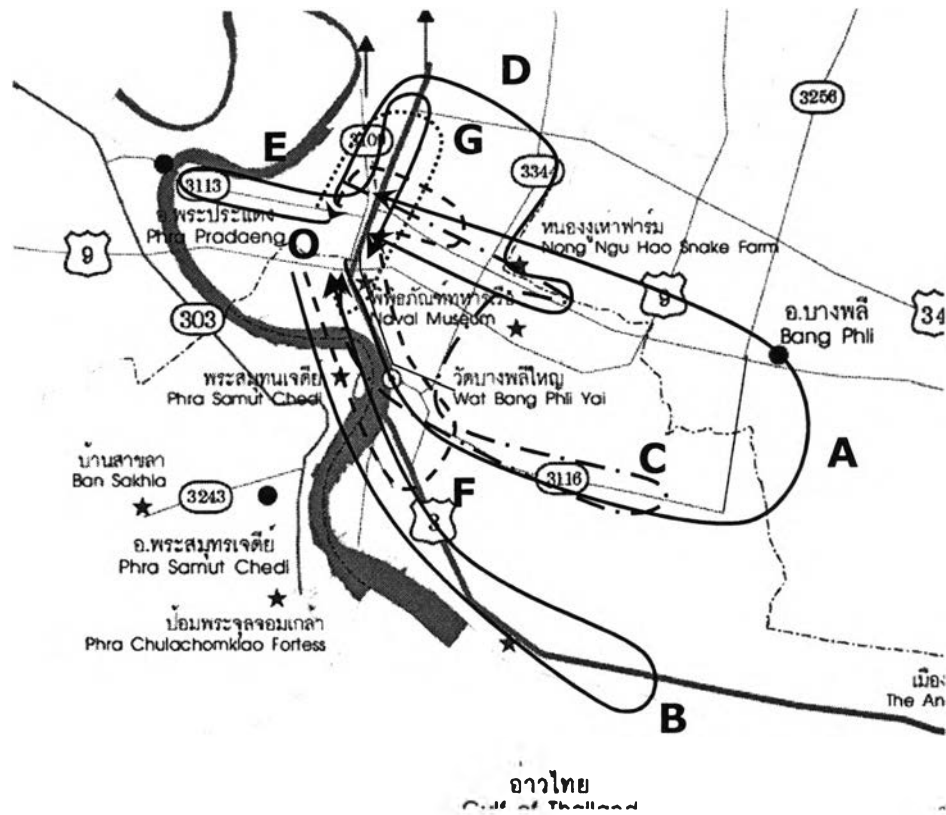


Figure 5.2 The results of design route

When comparing the results obtained from the new route design with the existing, there are significant improvements as shown in Table 5.2. The proposed system can improve efficiency of current system. The numbers of buses are reduced from 9 to 7 or 22%. The total travelling distance reduced from 231.08 km to 202.25 km or 12.48%. Finally, total time use reduces from 467.23 minutes to 458.33 minutes or 1.9%.

**Table 5.2** Comparison between current system and proposed system

|                           | <b>Current System</b> | <b>Proposed System</b> |                   |
|---------------------------|-----------------------|------------------------|-------------------|
|                           |                       | <b>Result</b>          | <b>Percentage</b> |
| <b>Total Routes</b>       | 9                     | 7                      | <b>22%</b>        |
| <b>Travelled Distance</b> | 231.08                | 202.25                 | <b>12.48%</b>     |
| <b>Time Use</b>           | 467.23                | 458.33                 | <b>1.90%</b>      |

### 5.1.2 Results refinement

From the result of the designed routes as shown in Table 5.1, there are 6 of the 7 routes that are full capacity. Those routes have no flexibility for adding new passengers, which may occur when there are new employees. However, one route has a lot of vacancies. If these vacancies are distributed to other routes, all routes will have flexibility to add some passengers without re-routing.

From the reasons above, the route can be redesigned by setting new maximum passengers in each route 47 persons by the following calculation.

$$\text{New maximum passengers} = \frac{\text{Total passengers}}{\text{The number of routes}} \quad (5.1)$$

$$\text{New maximum passengers} = \frac{323}{7} \approx 47$$

The program is rerun with the maximum number of passengers on each bus being 47. The resulting routes are shown in Figure 5.3 and Figure 5.4

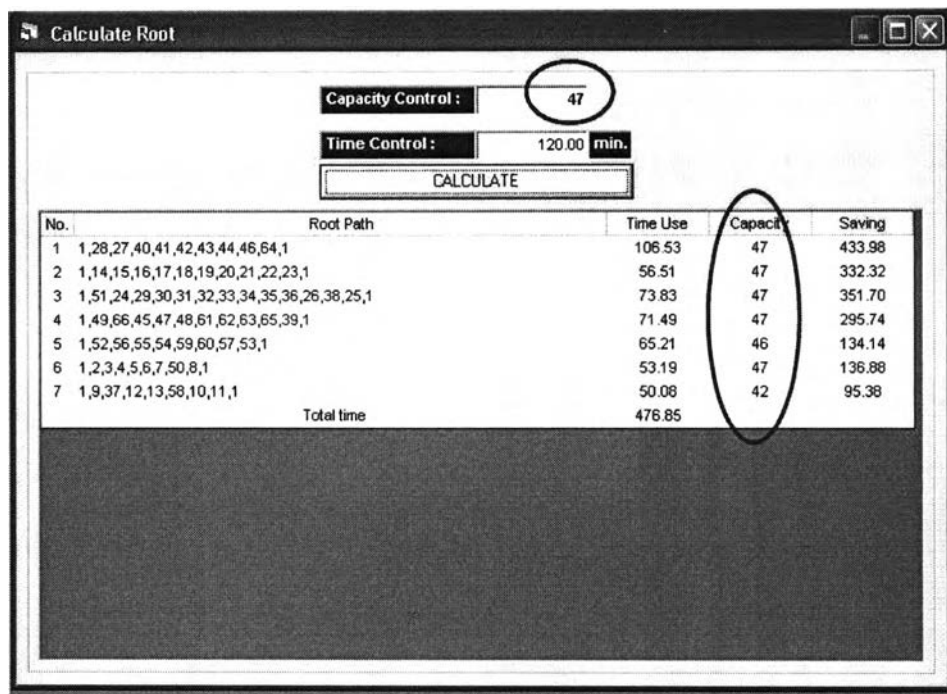


Figure 5.3 New bus routes with setting bus capacity of 47 persons

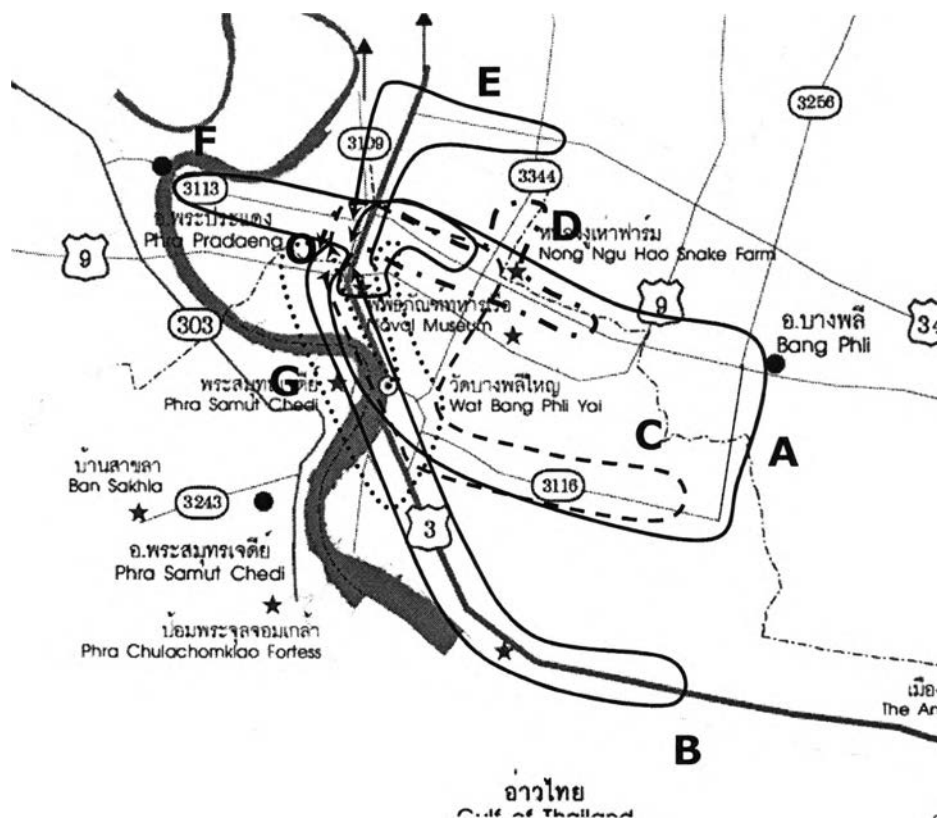


Figure 5.4 The results of new design route (for each route detail, see Appendix F)

With the new result, the number of passengers that each route can add varies from 3 to 8. However, the new routing is slightly less efficient in terms of distance and time as shown in Table 5.5. Since the increased distance and time are not very significant, the newly adjusted routing seems to be more appropriate. Its improvement from the current routing that the company is using is shown in Table 5.6.

**Table 5.3** Data in each route compare between old and new design route

| <b>Maximum Passengers</b> | <b>Route</b>                   | <b>A</b> | <b>B</b> | <b>C</b> | <b>D</b> | <b>E</b> | <b>F</b> | <b>G</b> | <b>Total</b>  | <b>Average</b> |
|---------------------------|--------------------------------|----------|----------|----------|----------|----------|----------|----------|---------------|----------------|
| <b>50 persons</b>         | <b>Passengers</b>              | 50       | 50       | 50       | 50       | 50       | 50       | 23       | <b>323</b>    | <b>46.14</b>   |
|                           | <b>Travelled Distance (km)</b> | 47.26    | 24.34    | 35.04    | 35.47    | 21.60    | 21.37    | 17.17    | <b>202.25</b> | <b>28.89</b>   |
|                           | <b>Time use (min)</b>          | 102.85   | 57.01    | 78.41    | 79.27    | 51.53    | 51.07    | 38.17    | <b>458.33</b> | <b>65.48</b>   |
| <b>47 persons</b>         | <b>Passengers</b>              | 47       | 47       | 47       | 47       | 46       | 47       | 42       | <b>323</b>    | <b>46.14</b>   |
|                           | <b>Travelled Distance (km)</b> | 49.35    | 24.34    | 33.00    | 31.83    | 28.77    | 22.68    | 21.54    | <b>211.51</b> | <b>30.22</b>   |
|                           | <b>Time use (min)</b>          | 106.53   | 56.51    | 73.83    | 71.49    | 65.21    | 53.19    | 50.08    | <b>476.85</b> | <b>68.12</b>   |

**Table 5.4** Percentage of Saving Comparison

|                           | Current System | Proposed System |               | Adjusted System |               |
|---------------------------|----------------|-----------------|---------------|-----------------|---------------|
|                           |                | Result          | Percentage    | Result          | Percentage    |
| <b>Total Routes</b>       | 9              | 7               | <b>22%</b>    | 7               | <b>22%</b>    |
| <b>Travelled Distance</b> | 231.08         | 202.25          | <b>12.48%</b> | 211.51          | <b>8.47%</b>  |
| <b>Time Use</b>           | 467.23         | 458.33          | <b>1.90%</b>  | 476.85          | <b>-2.06%</b> |

## 5.2 Discussion

### 5.2.1 Benefits of the proposed system

At present, the company's agreement to pay to the contractor is based on the number of buses used and the distance travelled. With the reduction of the number of buses from 9 to 7, and the travelling distance from 231 km to 211 km. The company can reduce its costs for providing the service to its employees significantly.

### 5.2.2 Drawbacks of the proposed system

As the saving algorithm by Clarke and Wright tries to minimise the number of vehicles for this kind of problem, it tries to fill the capacity of each vehicle. It is natural that the total distance and time that each vehicle travels will increase if the number of vehicles is reduced. It is also natural for this algorithm to make some routes that travel to far-away pick up points to go to far-away pick up points in the same direction. Therefore, some routes will be much longer than others.

As in Table 5.5, the distance travelled by each route varies from 21 km to 49 km, and the time from 50 minutes to 106 minutes. Passengers on long routes may not be satisfied with the time they have to spend on the bus. Besides, the average travel time for all routes is increased from 52 minutes to 68 minutes.

**Table 5.5** Comparing between current system and proposed system

|                        |                                |          |          |          |          |          |          |          |          |          |              |
|------------------------|--------------------------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|--------------|
| <b>Current System</b>  | <b>Route</b>                   | <b>1</b> | <b>2</b> | <b>3</b> | <b>4</b> | <b>5</b> | <b>6</b> | <b>7</b> | <b>8</b> | <b>9</b> | <b>Total</b> |
|                        | <b>Passengers</b>              | 42       | 30       | 40       | 31       | 34       | 46       | 33       | 39       | 28       | 323          |
|                        | <b>Travelled Distance(km)</b>  | 26.94    | 18.94    | 33.72    | 17.98    | 22.26    | 44.94    | 23.84    | 20.72    | 21.74    | 231.08       |
|                        | <b>Travelled Time (min)</b>    | 43.34    | 33.82    | 57.47    | 37.65    | 50.54    | 106.54   | 48.66    | 44.65    | 43.56    | 467.23       |
| <b>Proposed System</b> | <b>Route</b>                   | <b>A</b> | <b>B</b> | <b>C</b> | <b>D</b> | <b>E</b> | <b>F</b> | <b>G</b> |          |          | <b>Total</b> |
|                        | <b>Passengers</b>              | 47       | 47       | 47       | 47       | 46       | 47       | 42       |          |          | 323          |
|                        | <b>Travelled Distance (km)</b> | 49.35    | 24.34    | 33.00    | 31.83    | 28.77    | 22.68    | 21.54    |          |          | 211.51       |
|                        | <b>Travelled Time (min)</b>    | 106.53   | 56.51    | 73.83    | 71.49    | 65.21    | 53.19    | 50.08    |          |          | 476.85       |