**Heuristic Analysis:**

**Air Cargo Problem 1:**

The optimal plan is of plan length 6  with the following plan

Load(C1, P1, SFO)
Load(C2, P2, JFK)
Fly(P2, JFK, SFO)
Unload(C2, P2, SFO)
Fly(P1, SFO, JFK)
Unload(C1, P1, JFK)

Depth first search, methods, takes one path and traverses to the leaf level nodes and tries to find the solution to the problem. So, we see the plan length is not optimal. But the number of nodes expanded is optimum.

Bread-first search methods, processes the tree level by level. So, we can see the plan length is 6, which is the optimal plan length. But the number of expansions are more.

Hueristic functions, reduces the number of node expansions and provides us with the optimal solution in optimal time elapses. But none of the heuristics are accurate.
Out of all heuristic search with ignore pre-conditions gives the consistent optimal performance across all the problmes.

| Method | Expansions | Goal Tests | New nodes | Plan length | Time elapsed |
|---|---|---|---|---|---|
| 1. breadth_first_search | 43 | 56 | 180 | 6 | 0.03 |
| 2. breadth_first_tree_search | 1458 | 1459 | 5960 | 6 | 0.88 |
| 3. depth_first_graph_search | 21 | 22 | 84 | 20 | 0.012 |
| 4. depth_limited_search | 101 | 271 | 414 | 50 | 0.08 |
| 5. uniform_cost_search | 55 | 57 | 224 | 6 | 0.033 |
| 6. recursive_best_first_search h_1 | 4229 | 4230 | 17023 | 6 | 2.552 |
| 7. greedy_best_first_graph_search h_1 | 7 | 9 | 28 | 6 | 0.004 |
| 8. astar_search h_1 | 55 | 57 | 224 | 6 | 0.033 |
| 9. astar_search h_ignore_preconditions | 41 | 43 | 170 | 6 | 0.034 |
| 10. astar_search h_pg_levelsum | 11 | 13 | 50 | 6 | 1.092 |

**Air Cargo Problem 2:**

The optimal plan is of plan length 9, with the following plan

Load(C1, P1, SFO)
Load(C2, P2, JFK)

Load(C3, P3, ATL)
Fly(P1, SFO, JFK)
Fly(P2, JFK, SFO)
Fly(P3, ATL, SFO)
Unload(C3, P3, SFO)
Unload(C2, P2, SFO)
Unload(C1, P1, JFK)

| Method | Expansions | Goal Tests | New nodes | Plan length | Time elapsed |
|---|---|---|---|---|---|
| 1. breadth_first_search | 3343 | 4609 | 30509 | 9 | 12.55 |
| 3. depth_first_graph_search | 624 | 625 | 5602 | 619 | 3.23 |
| 5. uniform_cost_search | 4853 | 4855 | 44041 | 9 | 10.08 |
| 8. astar_search h_1 | 4853 | 4855 | 44041 | 9 | 10.69 |
| 9. astar_search h_ignore_preconditions | 1450 | 1452 | 13303 | 9 | 3.8 |

Other methods were taking longer time more than 10 mins

**Air Cargo Problem 3:**

The optimal plan is of plan length 12, with the following plan
Load(C2, P2, JFK)
Fly(P2, JFK, ORD)
Load(C4, P2, ORD)
Fly(P2, ORD, SFO)
Unload(C4, P2, SFO)
Load(C1, P1, SFO)
Fly(P1, SFO, ATL)
Load(C3, P1, ATL)
Fly(P1, ATL, JFK)
Unload(C3, P1, JFK)
Unload(C2, P2, SFO)
Unload(C1, P1, JFK)

| Method | Expansions | Goal Tests | New nodes | Plan length | Time elapsed |
|---|---|---|---|---|---|
| 1. breadth_first_search | 14663 | 18089 | 129631 | 12 | 90 |
| 3. depth_first_graph_search | 408 | 409 | 3364 | 392 | 1.5 |
| 5. uniform_cost_search | 18223 | 18225 | 159618 | 12 | 44.16 |
| 8. astar_search h_1 | 18223 | 18225 | 159618 | 12 | 47. 30 |
| 9. astar_search h_ignore_preconditions | 5040 | 5042 | 44944 | 12 | 14.6 |

Other methods were taking longer time of more than 10 mins.
The detailed log are present in the respective log files.