**Routine Inspection Optimisation Formulation v3**

### Decision variables

The model makes three types of decisions simultaneously; the selection of *what* jobs to undertake, the assignment of *who* should do these, and in *which* sequence these should be scheduled.

|  |  |
| --- | --- |
|  | 1 if node is visited by crew |
|  | Completion time of job |
|  | Penalty indicator of job going overdue |

### Objective function

|  |
| --- |
|  |

The objective function combines the score of each job, travel time, and the cost of potentially missing contractually nominated response times.

### Constraints

1. **Inspection segments must be completed by one crew:** Some roads can also be inspected in either forwards or backwards direction. If segment is bidirectional, then we either traverse it from start to end or vice versa. If it is not bidirectional, we must traverse it from start to end.

|  |  |  |
| --- | --- | --- |
|  |  | (1) |
|  |  | (2) |
|  |  | (3) |

1. **Conservation of flow:** If a crew enters a job, it must also leave. (Optional constraint as it is already enforced by the other constraints. Removed in code as it increased solving time.)

|  |  |  |
| --- | --- | --- |
|  |  | (4) |

1. **One crew per job:** At most only one crew and leave and enter a job.

|  |  |  |
| --- | --- | --- |
|  |  | (5) |
|  |  | (6) |

1. **Crew tour:** If a job is completed, then ensure that we leave and enter the job.

|  |  |  |
| --- | --- | --- |
|  |  | (7) |
|  |  | (8) |

1. **Crew tour:** A crew cannot visit itself.

|  |  |
| --- | --- |
|  | (9) |

1. **Designated depots:** Crews must depart and return to their designated depots.

|  |  |  |
| --- | --- | --- |
|  |  | (10) |
|  |  | (11) |

1. **Non-designated depots:** Crews cannot enter or leave a depot that is not designated to that crew.

|  |  |  |
| --- | --- | --- |
|  |  | (12) |
|  |  | (11) |

1. **Temporal constraints**: The time to complete job is greater than or equal to the sum of the completion time of the prior job , the estimated job duration as well as the travel time. If job is not the prior job, the big-M constraint just ensures that the time a positive value.

|  |  |  |
| --- | --- | --- |
|  |  | (14) |

where . is a tight upper bound as completion times will always be less than the shift end times.

1. **Shift time constraints:**

**Shift start**: The first job (Immediately leaving the depot) completion time must be completed at a time greater than or equal to the sum of the shift time start of that crew, the estimated job duration as well as the travel time. If job is not the first job, this constraint just ensures the time is a positive value.

|  |  |  |
| --- | --- | --- |
|  |  | (15) |

**Shift end**: The last job (Immediately before returning to the depot) completion time must be less than or equal to the shift end time of that crew subtract the travel time. If job is not the last job, then the big-M constraint ensures the time is a positive value.

|  |  |  |
| --- | --- | --- |
|  |  | (16) |

where

1. **Crew type constraints:** For all jobs that is not compatible with crew , we cannot enter or leave that job.

|  |  |  |
| --- | --- | --- |
|  |  | (17) |
|  |  | (18) |

1. **Penalty constraints:** The penalty indicator is active if and only if the job completion time is over the due date.

|  |  |  |
| --- | --- | --- |
|  |  | (19) |
|  |  | (20) |

Where