IMPROVED SHORT-TERM DECISION MAKING FOR OFFSHORE WIND FARM VESSEL ROUTING

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Introduction

- On the day planning maintenance actions at an offshore wind farm:
  - Which vessels to use?
  - Which turbines to visit?
  - In what order should repairs be carried out?
- Vessel routing is still planned without the use of decision support tools
- Low accessibility during winter
- High uncertainties (failure diagnosis, repair duration, human error, transfer onto turbine not always possible)

Methodology

- Inner and outer problem approach
- Heuristic method: Cluster matching algorithm
- Value = Rewards – costs
- Simulation running time: user dependent

What is not modelled

- Different grades of technicians
- Vessel stays with turbine during repair

What is modelled

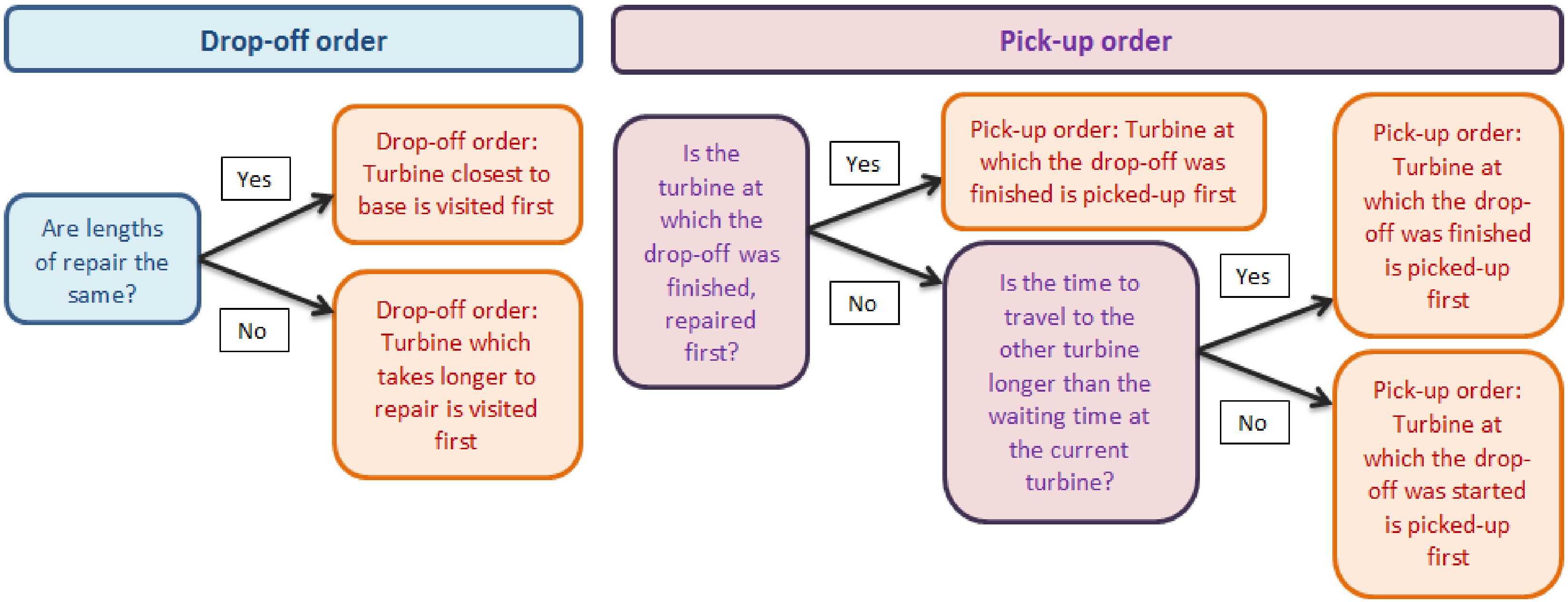
- Multiple O&M bases
- Constraints:
  - Time
  - Number of technicians available
  - Vessel capacity (technicians and load)
- Variable vessel speed (slower when at farm)
- One day planning horizon only
- Up to 4 turbines per vessel
- One crew can visit maximum of 2 turbines per day
- Costs: fuel, vessel hire, repair cost
- Probabilities

Outer problem – heuristic method

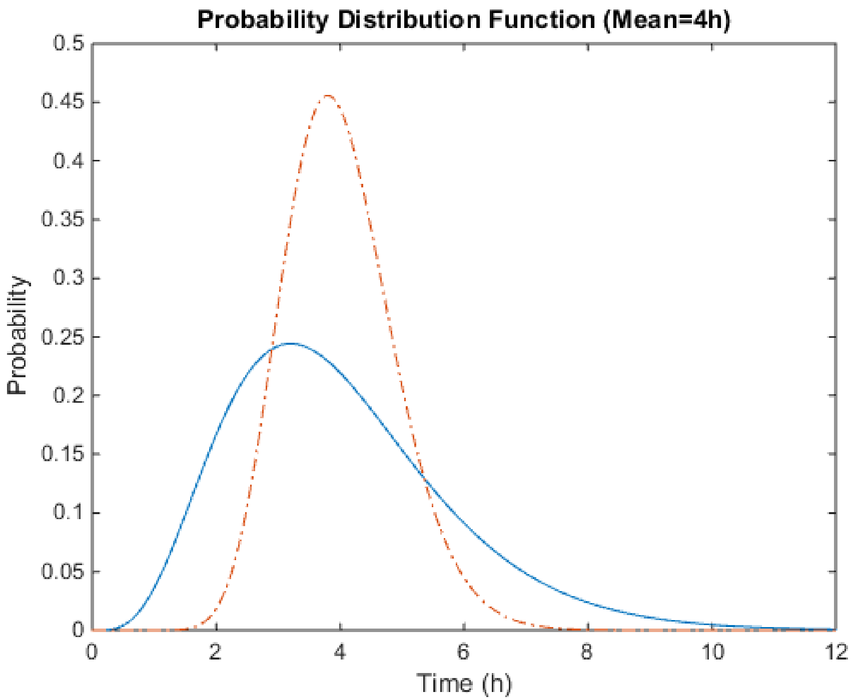
- Cluster matching algorithm
- Procedure:
  - Generate all possible clusters with up to 4 turbines per vessel
  - Calculate value (and feasibility) of each cluster
    - Rank each cluster by value (or value per technician used, or a combination of those)
  - Pick best cluster
  - Pick next best that meets constraints
  - Repeat the above as many times as there is time for

Inner problem: logic flowcharts

- Computationally effective & accurate
- Objective: minimise time taken by a policy & no. of technician used
- More advanced solution may be required if more than 5 turbines can be visited by one vessel
- Example: logic for 1 vessel, 2 turbines (both “lengthy” repairs)



Model inputs



1	0.8	0.5	(
1	0.8	0.5	(
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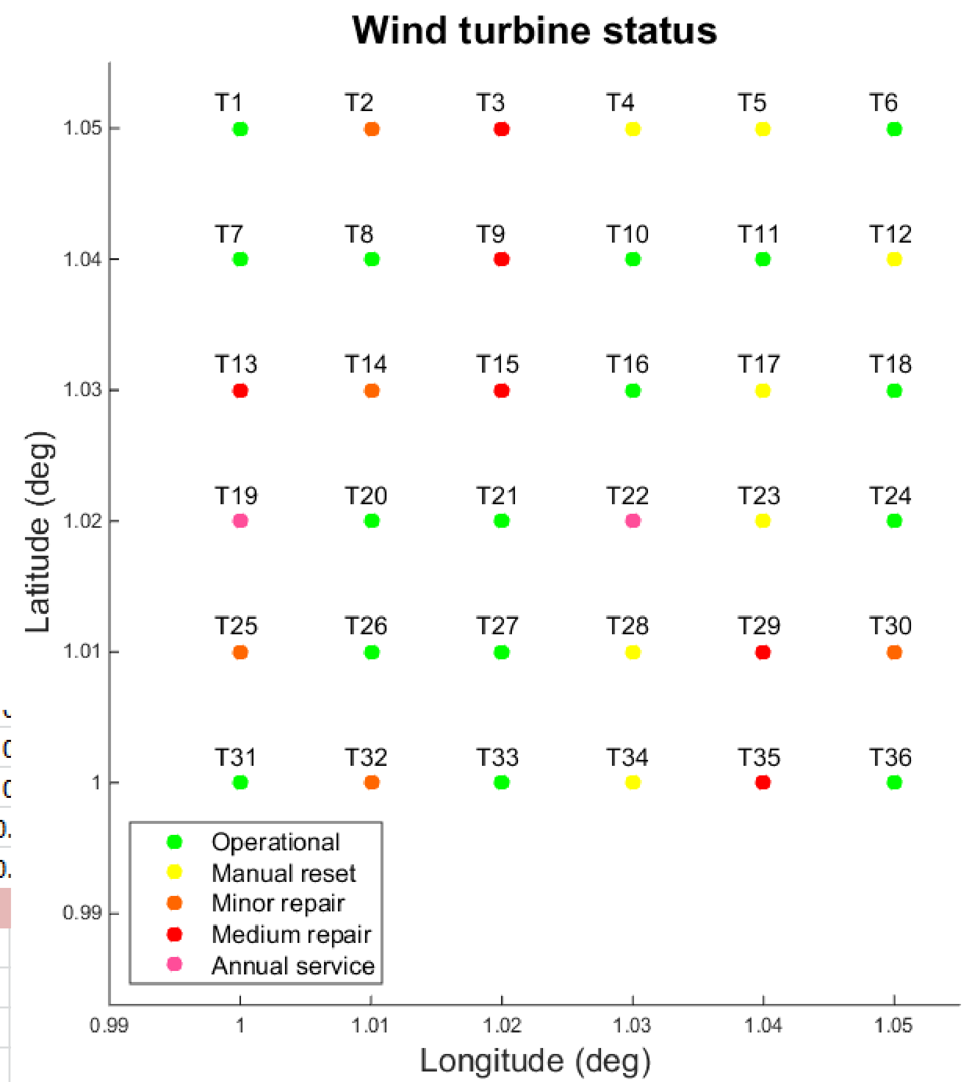
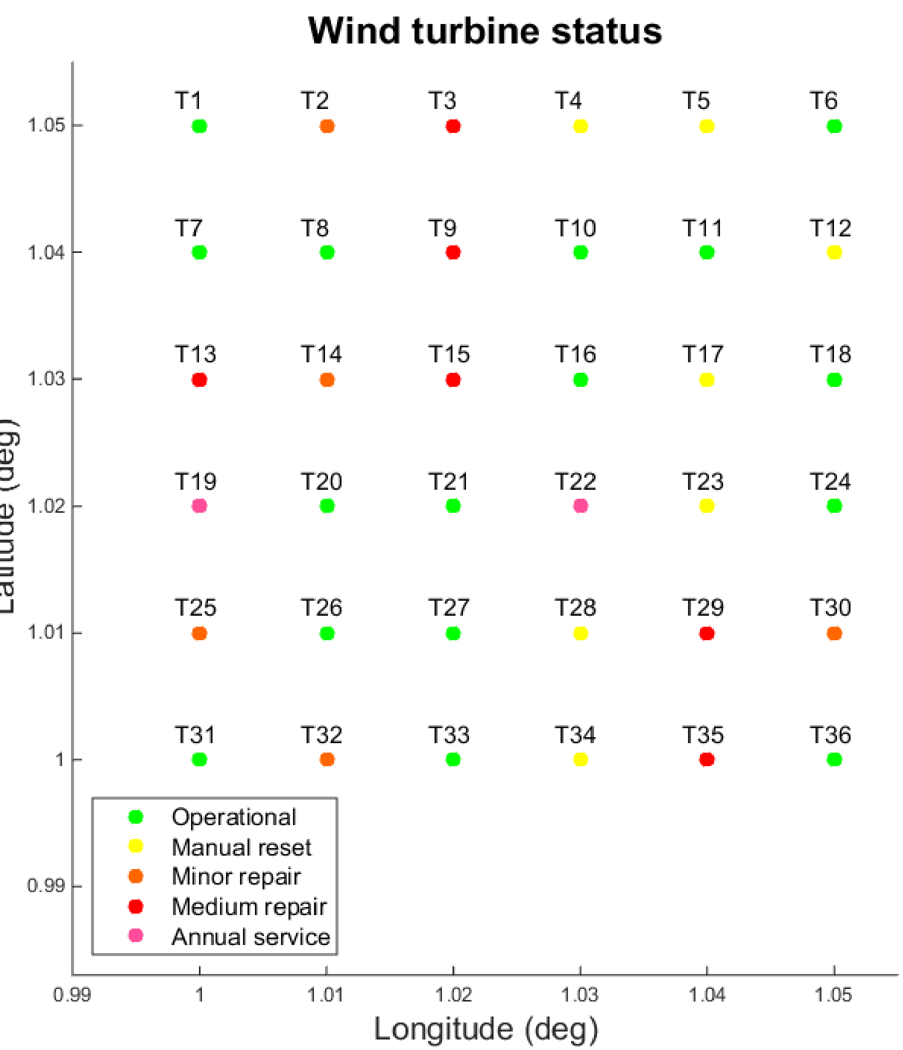
1	1	0.75	0.

Repairs	Time required (h)	Technicians required
Manual reset	2	2
Minor repair	4	3
Medium repair	6	3
Annual service	6	2



Output: Vessel dispatch strategy

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OPTIMAL POLICY:
Dispatch vessel 1 to:
Wind turbine T29     (Medium repair)
Wind turbine T30     (Minor repair)
Wind turbine T34     (Manual reset)
Gantt Chart is located in Sheet 6.
Probability of successfully carrying out this policy is 1.9177%
Vessel 1 order:
    'T29'    'T30'    'T34'    'T34'    'T30'    'T29'

Dispatch vessel 2 to:
Wind turbine T14     (Minor repair)
Wind turbine T15     (Medium repair)
Gantt Chart is located in Sheet 3.
Probability of successfully carrying out this policy is 5.9895%
Vessel 2 order:
    'T15'    'T14'    'T14'    'T15'

Dispatch vessel 3 to:
Wind turbine T19     (Annual service)
Wind turbine T22     (Annual service)
Wind turbine T25     (Minor repair)
Wind turbine T28     (Manual reset)
Gantt Chart is located in Sheet 10.
Probability of successfully carrying out this policy is 11.0523%
Vessel 3 order:
    'T22'    'T19'    'T25'    'T28'    'T28'    'T22'    'T19'    'T25'
Dispatch vessel 4 to:
Wind turbine T2     (Minor repair)
Wind turbine T3     (Medium repair)
Wind turbine T4     (Manual reset)
Wind turbine T5     (Manual reset)
Gantt Chart is located in Sheet 8.
Probability of successfully carrying out this policy is 3.3079%
Vessel 4 order:
    'T5'    'T3'    'T2'    'T5'    'T4'    'T2'    'T4'    'T3'
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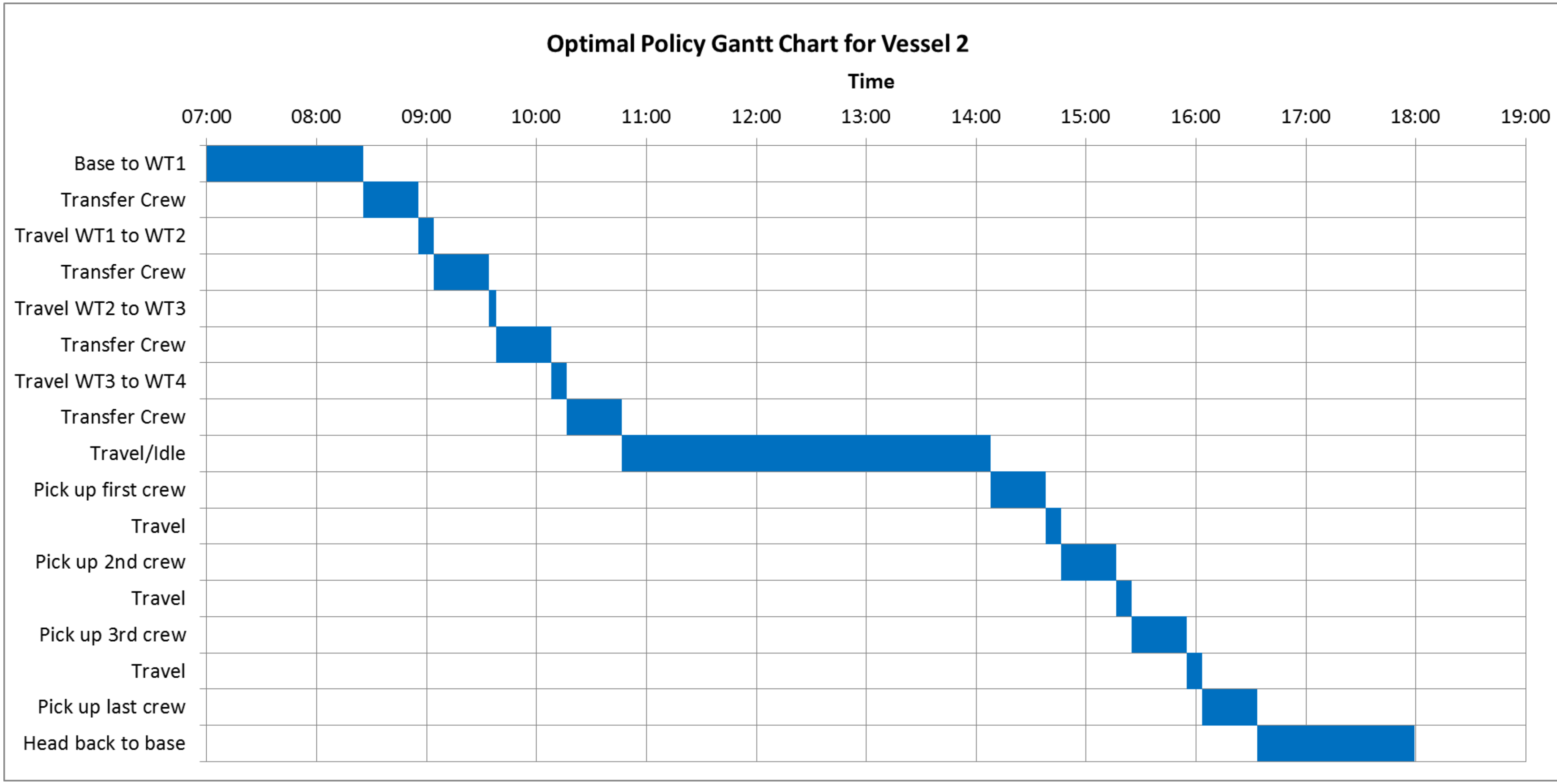
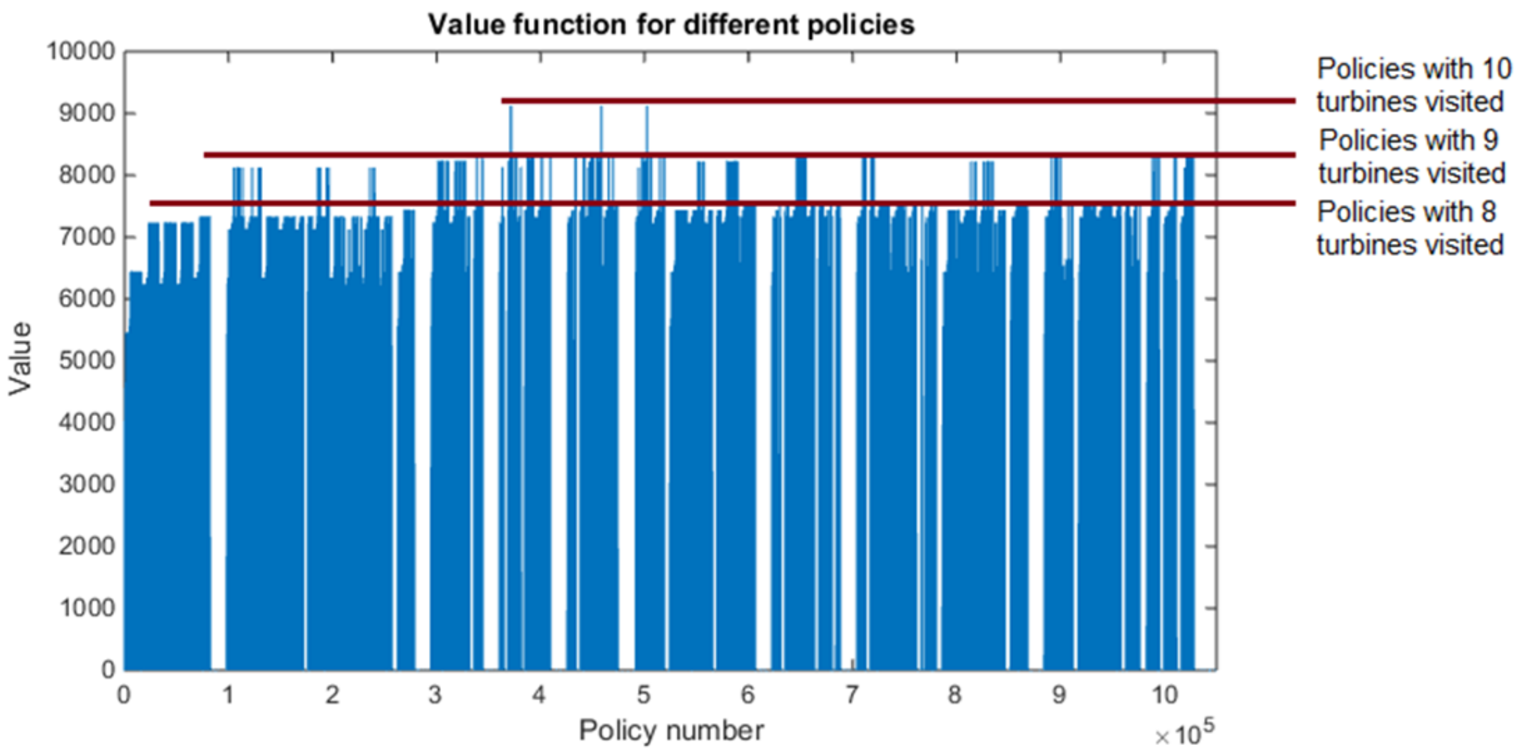
Output: Gantt chart



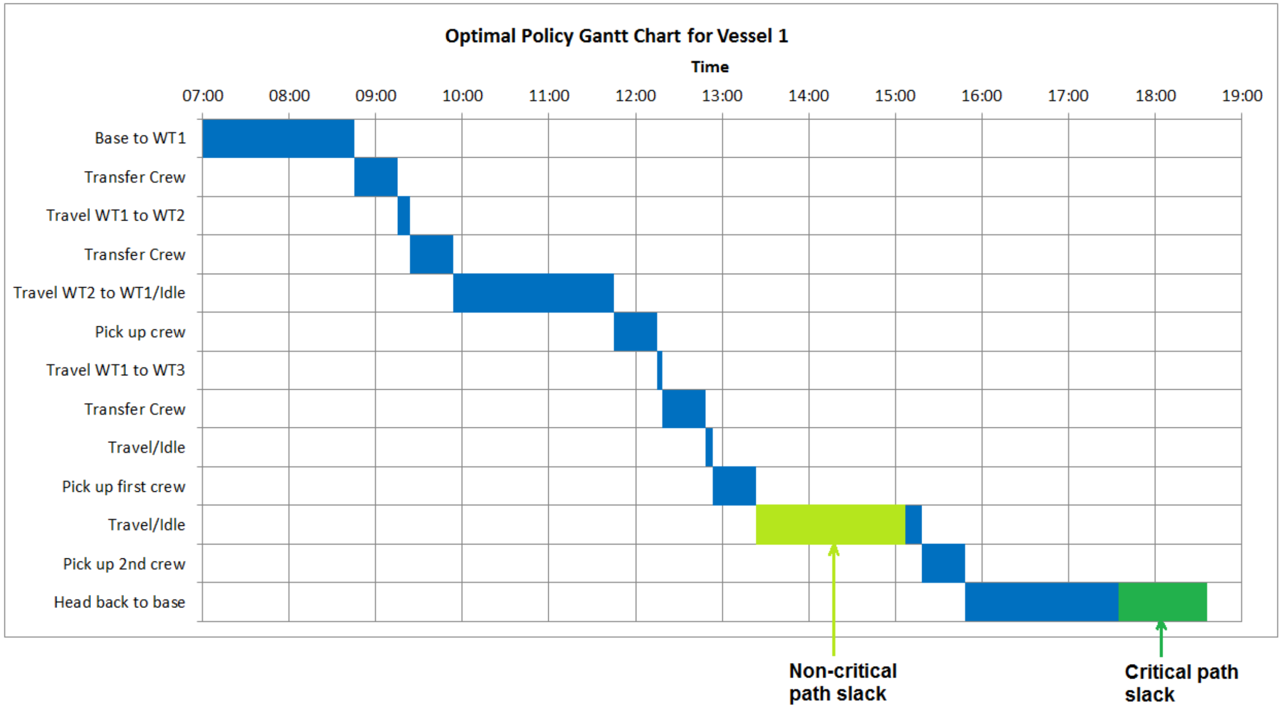
Output: Value function

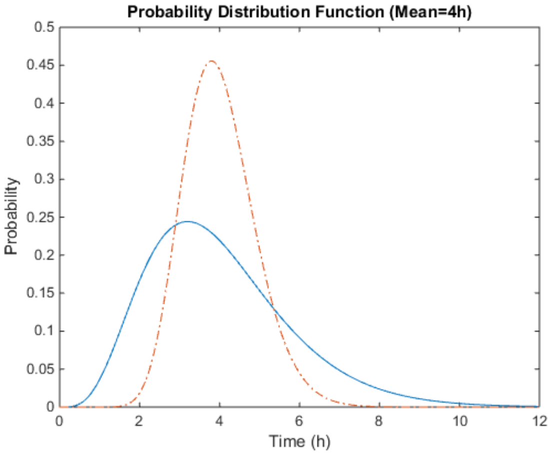
- In some instances, only a handful of policies can visit the maximum number of turbines



Probability

- Probability of successfully carrying out a policy is calculated. Factors considered (user inputs):
  - Probability of successful transfer from a given vessel onto turbine
  - Probability of each individual repair not taking longer than the expected duration + slack time
  - Probability of correct diagnosis
- Should a value be placed on this probability to influence the process of selecting the optimal decision?





Summary

Conclusions

Other models in academia solve the theoretical rather than the practical problem

Assumptions & inputs verified by offshore O&M operator

User-friendly outputs

Computational time can be changed depending on the desired accuracy

"Repair probability" variable can be used to discourage policies which are highly unlikely to be successful

Future Work

Assess the importancy of getting the estimated time of repair right

Does encouraging low-risk policies work?

More in-depth real life case studies

Practical application/commercialisation

Questions?

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