Simulation and Optimisation of Offshore Renewable Energy Arrays for Minimal Life-Cycle Costs

R. Kuipers

November 12, 2019

The problem

- Focus on modern windfarms in the North Sea, relatively far from the coast, 100+ wind turbines, lifespan of about 20-30 years, costs of installation in range of £100 million or higher
- Optimize logistics of operations on offshore windfarms (OWFs) in each phase of the life-cycle:
  - Installation
  - Maintenance
  - Decommission
- Logisitical descisions consists of layout, vessel scheduling, routing, number and types of vessels
- Small optimisations can have significant effects on costs, as vessels can cost upwards of £100,000 per day
- Methods used are optimisation and simulation

Key challenges

- Long lead-up times for many decisions means no last-minute scheduling
- Maritime weather conditions can be unpredictable
- Looking at the whole life-cycle includes a lot of different types of decisions
- Location-specific circumstances can have a big effect on weather conditions and duration of tasks
- Phases are not independent, maintenance starts at the same time installation starts

Research objectives

- Design an integrated optimisation and simulation model spanning the entire life-cycle of an Offshore Wind Farm, based on sub-models for each phase of the life-cycle.
- Sub-objectives:
  - Design an integrated optimisation and simulation model for the installation projects of an OWF.
  - Design an integrated optimisation and simulation model for the maintenance projects of an OWF.
  - Design an integrated optimisation and simulation model for the decommissioning projects of an OWF.

Existing literature

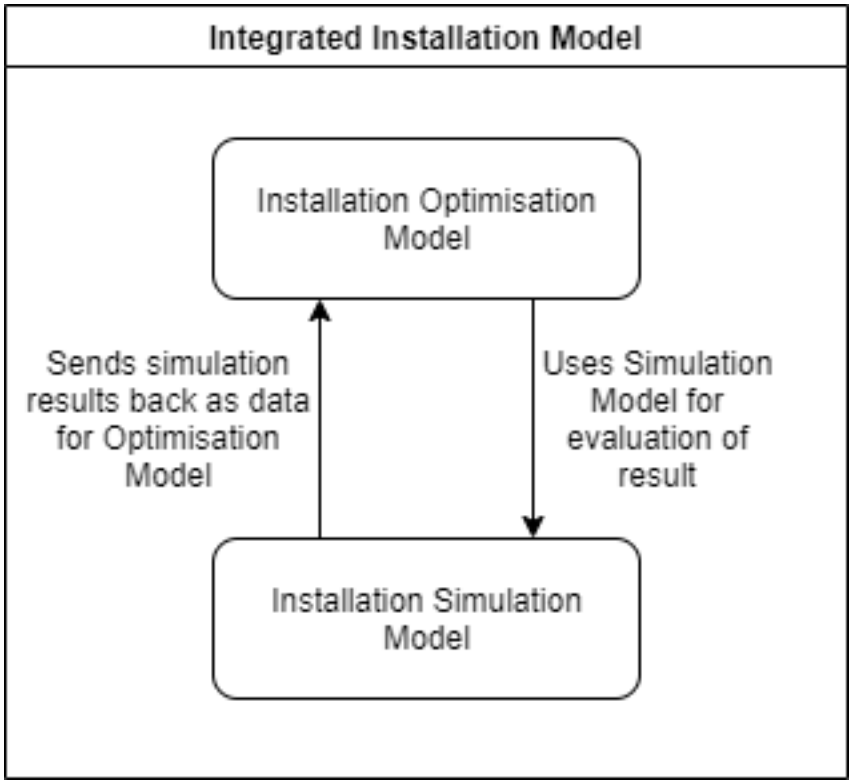
- Various attempts to improve the installation phase, through integer programming and local search, combined with simulation
- A lot of research has been done in various areas of maintenance, including supply chain management, mitigating failure rate, condition based maintenance
- Not a lot of research has been done on decommission projects, but they are similar in structure to installation projects
- No research at all has been found that looks at the entire life-cycle and how the different phases affect each other

Current Progress

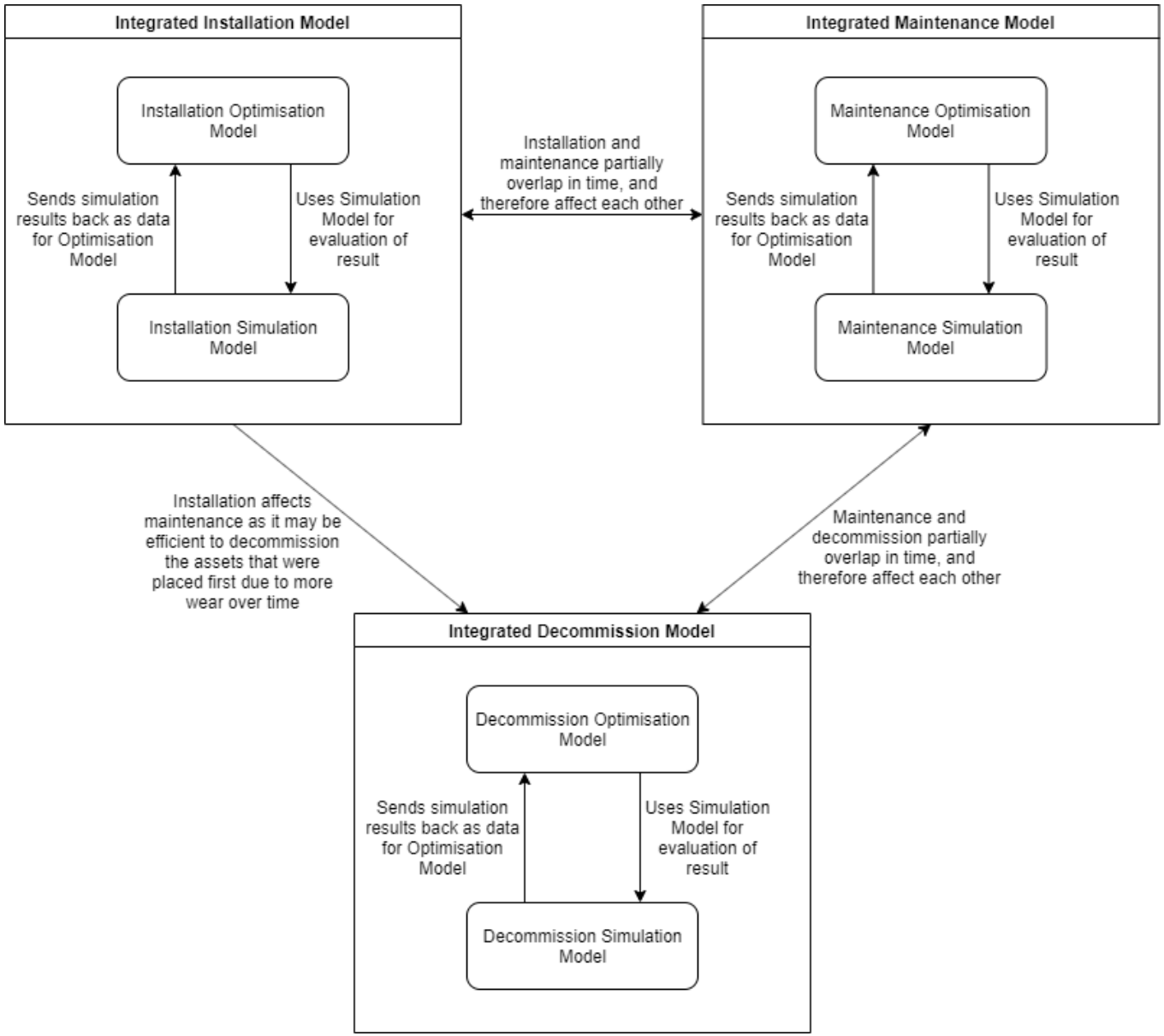
- Reviewed a large part of the literature, primarily on installation projects and secondarily on maintenance projects and general non-deterministic scheduling and logistics
- Laid the foundations for a decision support tool suited to analyse and optimise schedules for any phase of the life-cycle, based on site-specific characteristics of the project
- Planned the interactions between my various models

Model interactions - 1

- Primary process pipeline:
  1. Optimisation Model (OM) gets info about the site and task structure
  2. OM calculates new/improves existing schedule and sends it to the Simulation Model (SM)
  3. SM runs simulations with the schedule, returns metrics back to OM
  4. OM determines that end conditions are met or returns to step 2



Model interactions - 2



Future Work

- Develop full models for each stage of the life-cycle
- Determine specific interactions between the stages
- Implement models in the tool, develop it further for full commercial functionality
- Validate and test the tool (and underlying models) using real data