

Short-term O&M Risk Management when using Cranes

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Innovate UK

Project Consortium



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Science: David McMillan & Matthew Revie



Romax Insight: Wind Turbine
Condition Monitoring



Datalytics: Software and
User Interface Design

Utilities: Wind Farm Owners
and Operators



Funders:

Innovate UK

EPSRC

Engineering and Physical Sciences
Research Council

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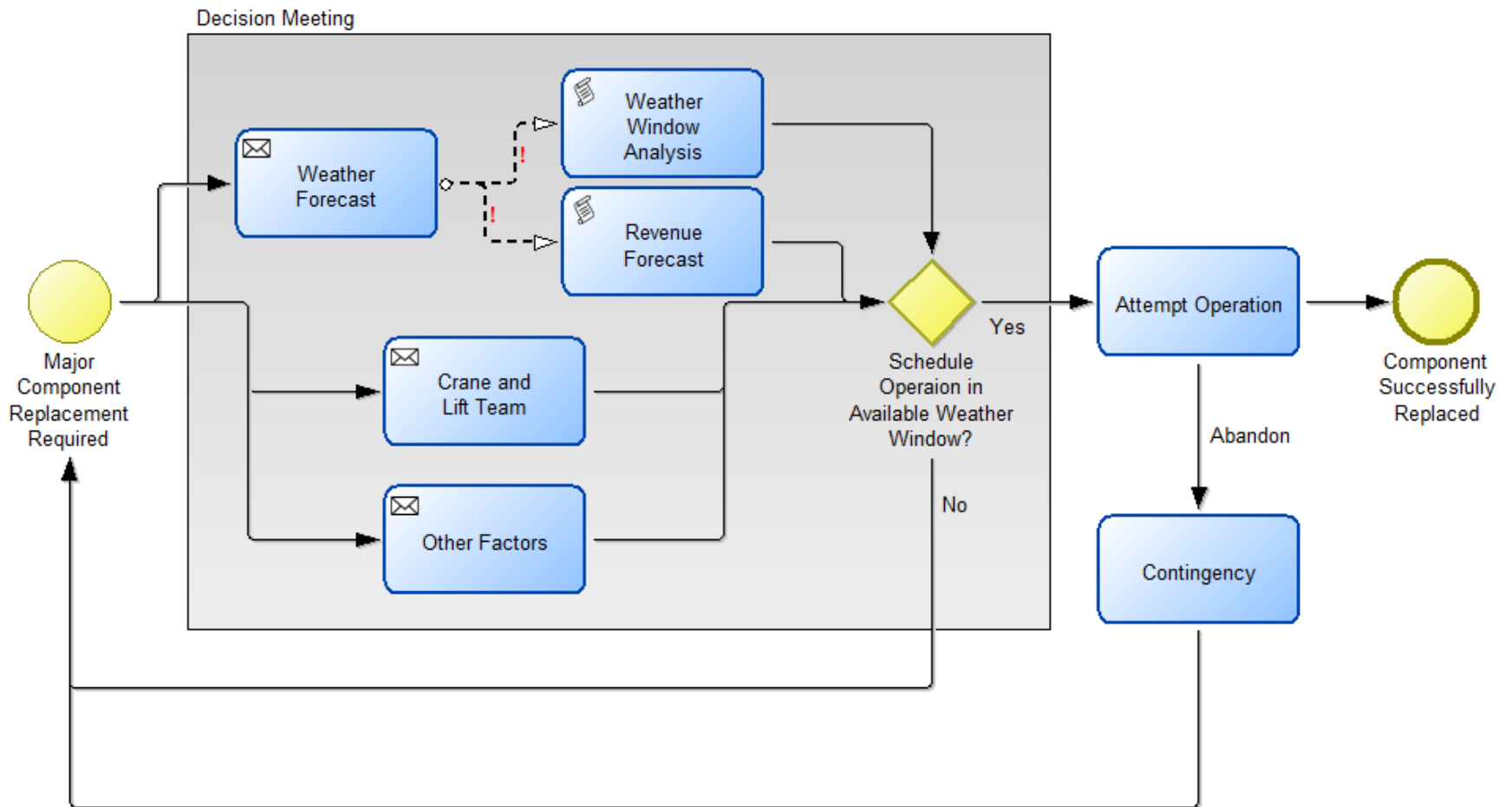
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- Heavy Lift Cost Model
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- Inputs:
 - User Defined
 - Background
- Outputs & Performance



Problem Statement

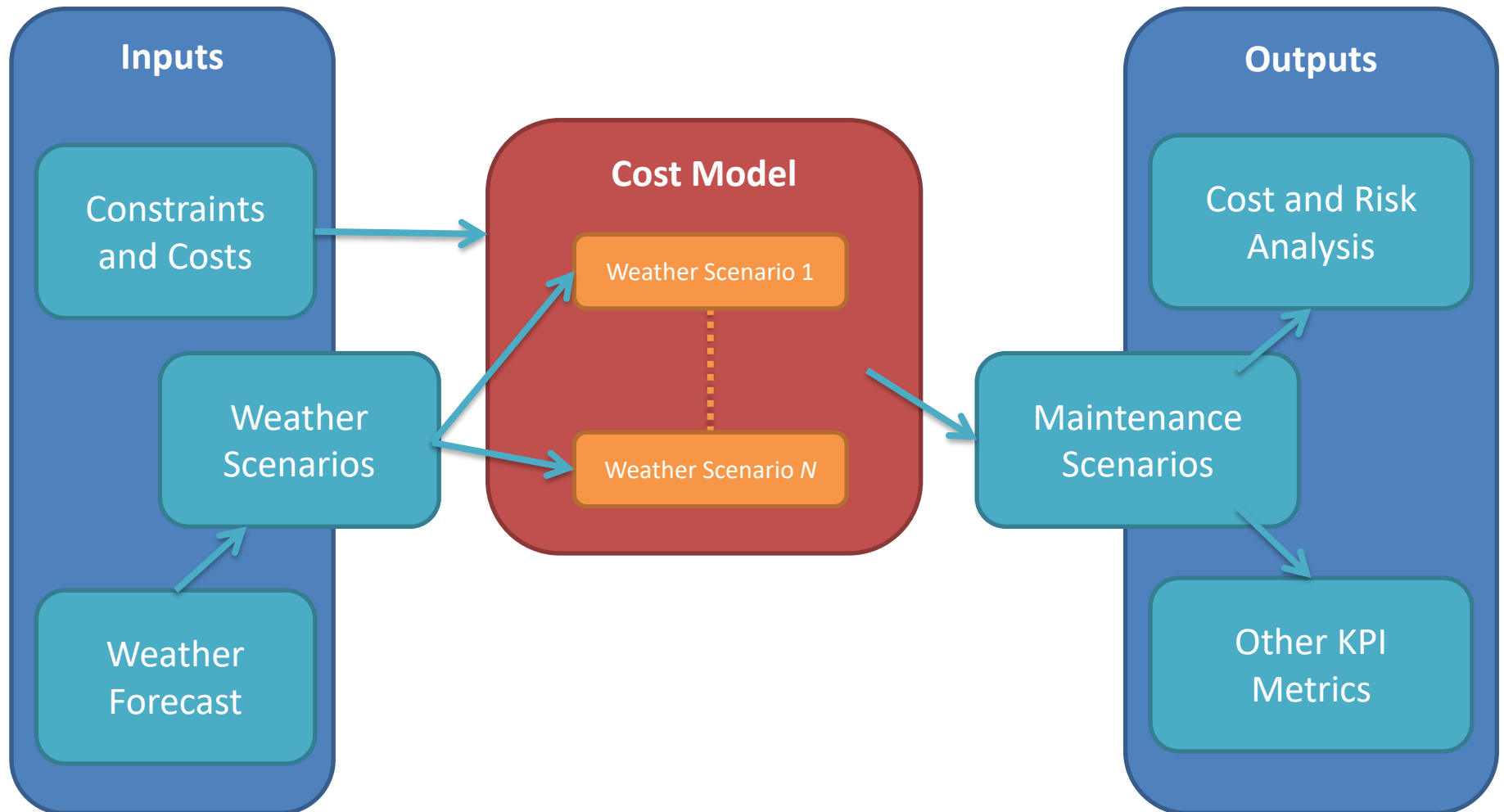
- Heavy lift operations are constrained by the availability of cranes and crew and weather restrictions.
- Decision support should quantify weather forecast uncertainty in terms of:
 - Expected cost
 - Risk associated with cost or particular events
 - Availability
 - Other KPIs?

Problem Statement

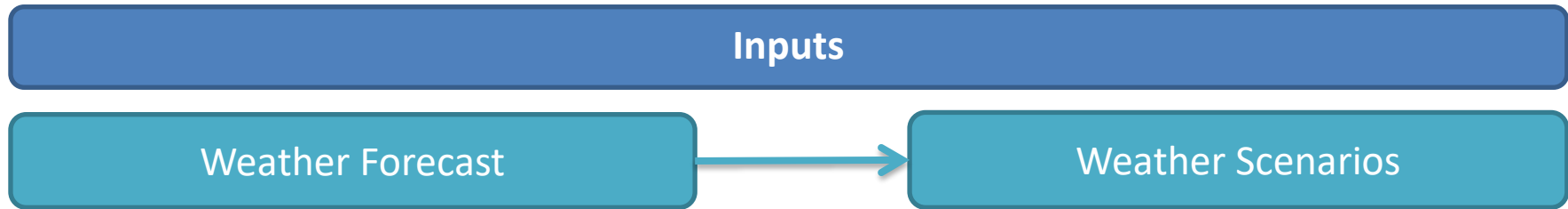


Approach

Stochastic Programme



Scenario Forecasts



- Numerical Weather Predictions from GFS/NOAA
- Post-processed for wind farm or individual turbine
- Probabilistic forecast produced as required for scenario generation

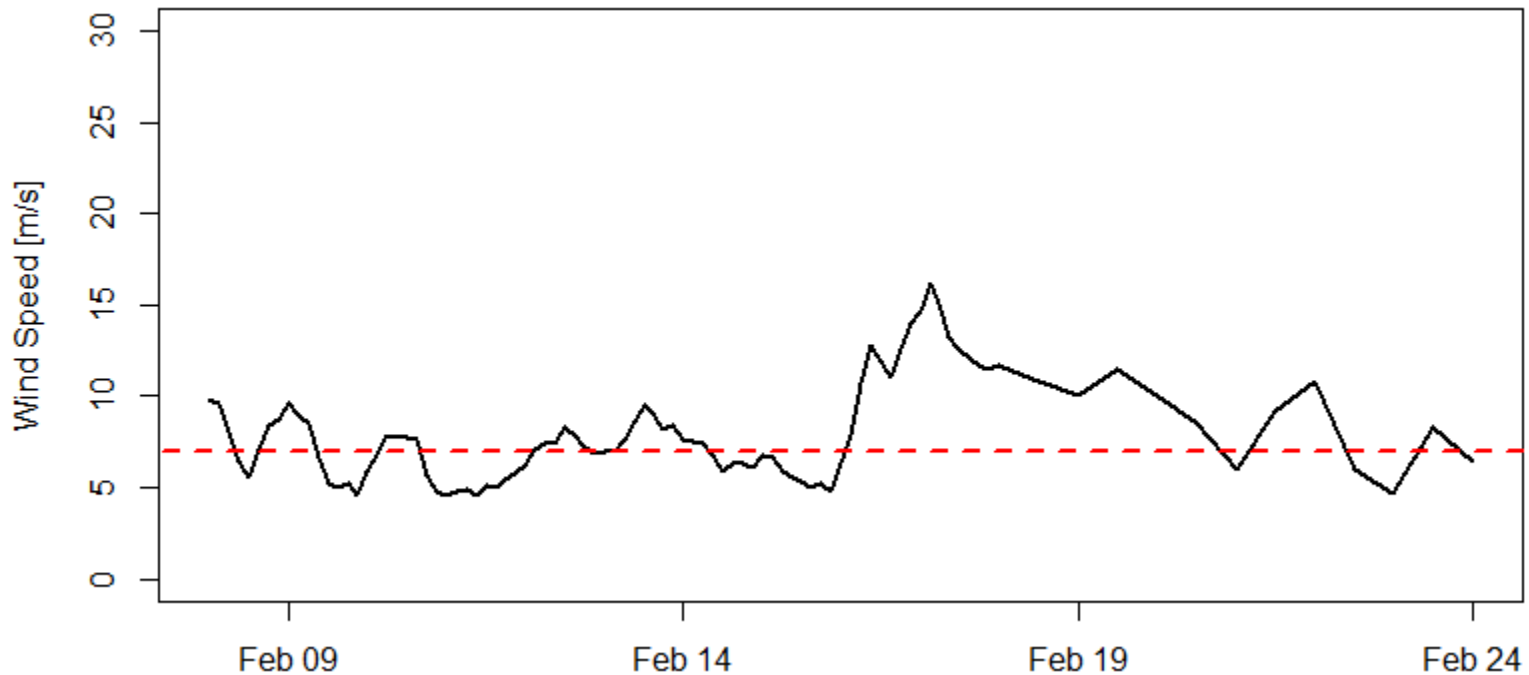
- Forecast errors sampled from statistical model
- Error model captures forecast uncertainty and temporal correlation

Scenario Forecasts

Inputs

Weather Forecast

Weather Scenarios

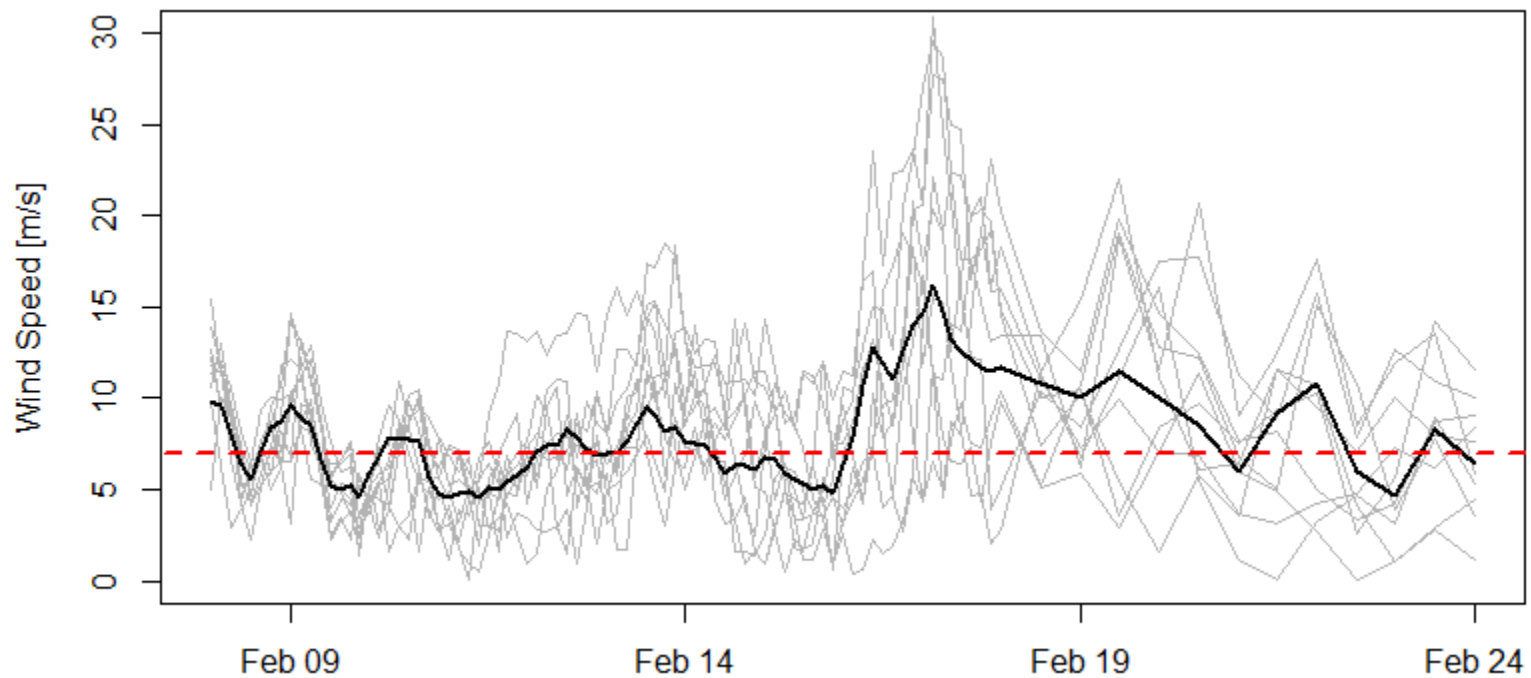


Scenario Forecasts

Inputs

Weather Forecast

Weather Scenarios

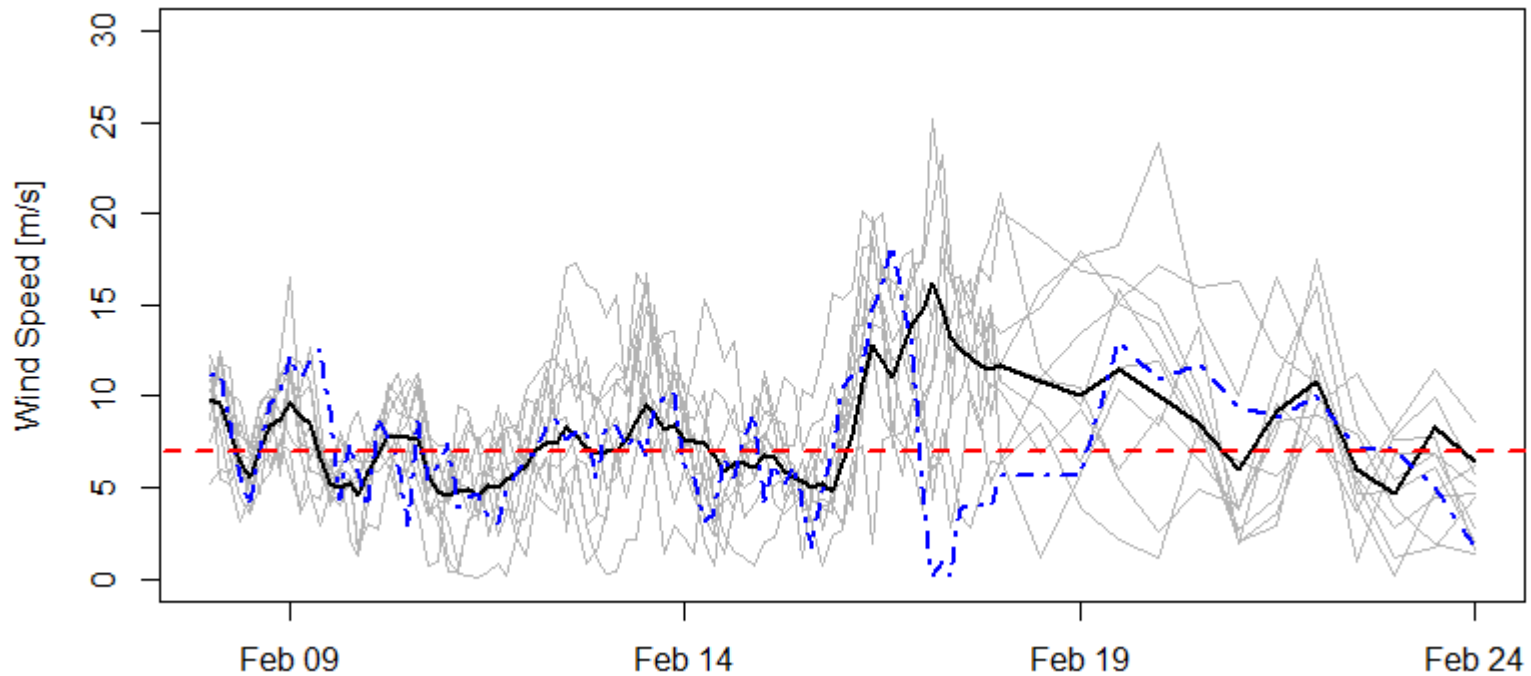


Scenario Forecasts

Inputs

Weather Forecast

Weather Scenarios



Inputs

Inputs

Constraints and Costs

Variable

Is turbine operational before repair?
Availability of crane/crew
Crane/crew day-rate
Additional-day day-rate
Max additional days
Time constrains (blocks)
Other no-work constraint
Schedule/Go-No-Go

Constant

Wind speed constraint
Contingency cost
Value of Power [£/MWh]
Turbine Rating/Power Curve
Working Hours (Start/End of Day)

Heavy Lift Cost Model

Cost Model

Part 1: Within Forecast Horizon

Part 2: Beyond Forecast Horizon

- Two Modes:
 1. Planned Operation, Go/No-Go
 2. Schedule Operation
 - Calculate costs associated with proceeding with operation. Assumes rational decision-maker!
- If operation not complete within forecast horizon, estimate cost to time of repair: lost revenue, crane hire.
 - Based on historic wind speed record
 - Crane/crew availability not captured

Heavy Lift Cost Model

Cost Model

Part 1: Within Forecast Horizon

Operation divided into “blocks” of time which require continuous period of good weather.

1. Find weather windows
2. Allocate job blocks to weather windows
3. Calculate operation costs
4. Calculate revenue (from generation)

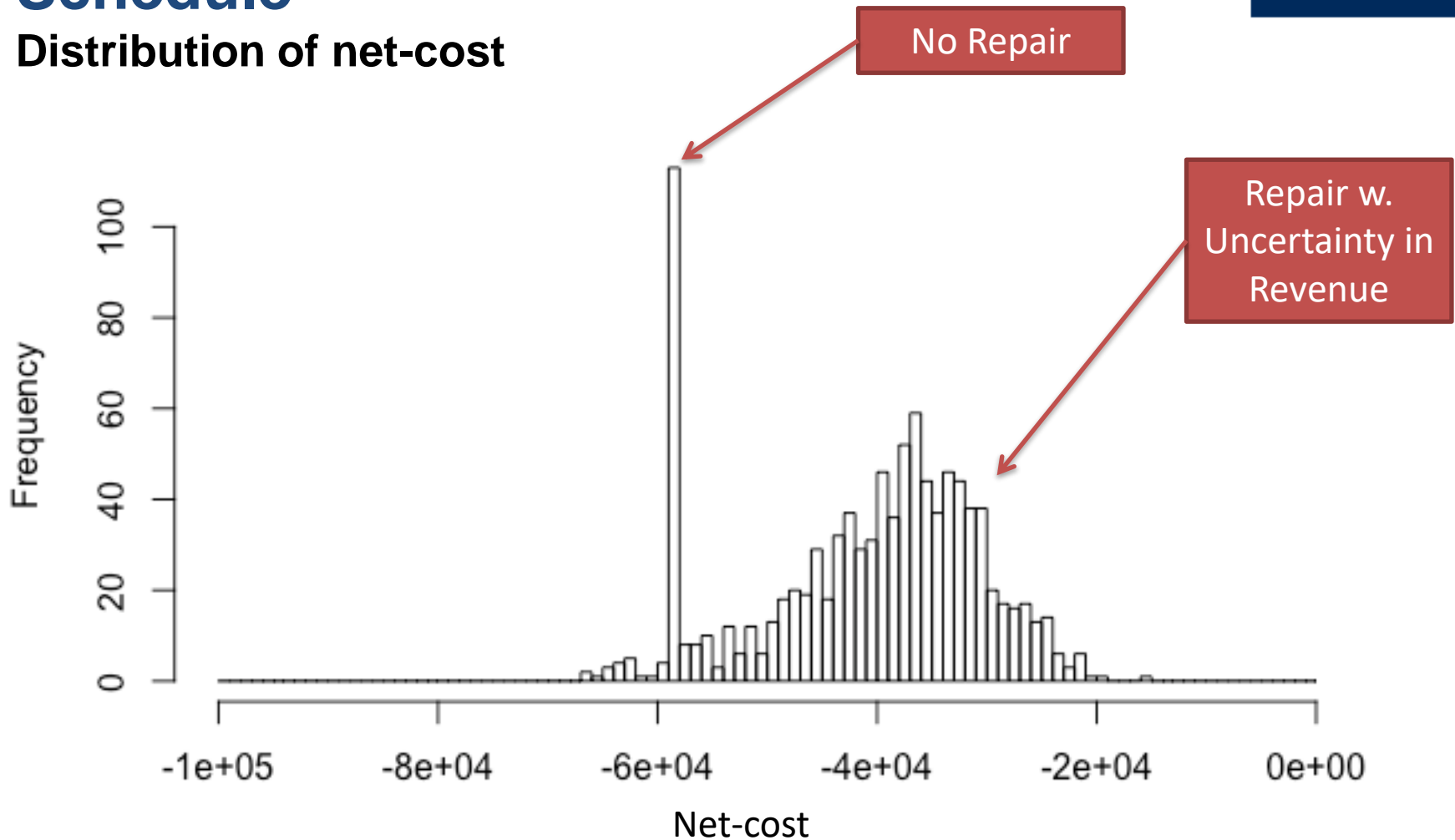
Outputs

- By scenario:
 - Cost
 - Complete/Contingency/Not Complete
 - Down-time
- Overall:
 - Distribution of costs for each option
 - Expected value
 - Risk analysis
 - Other KPIs, e.g. availability

Outputs

Schedule

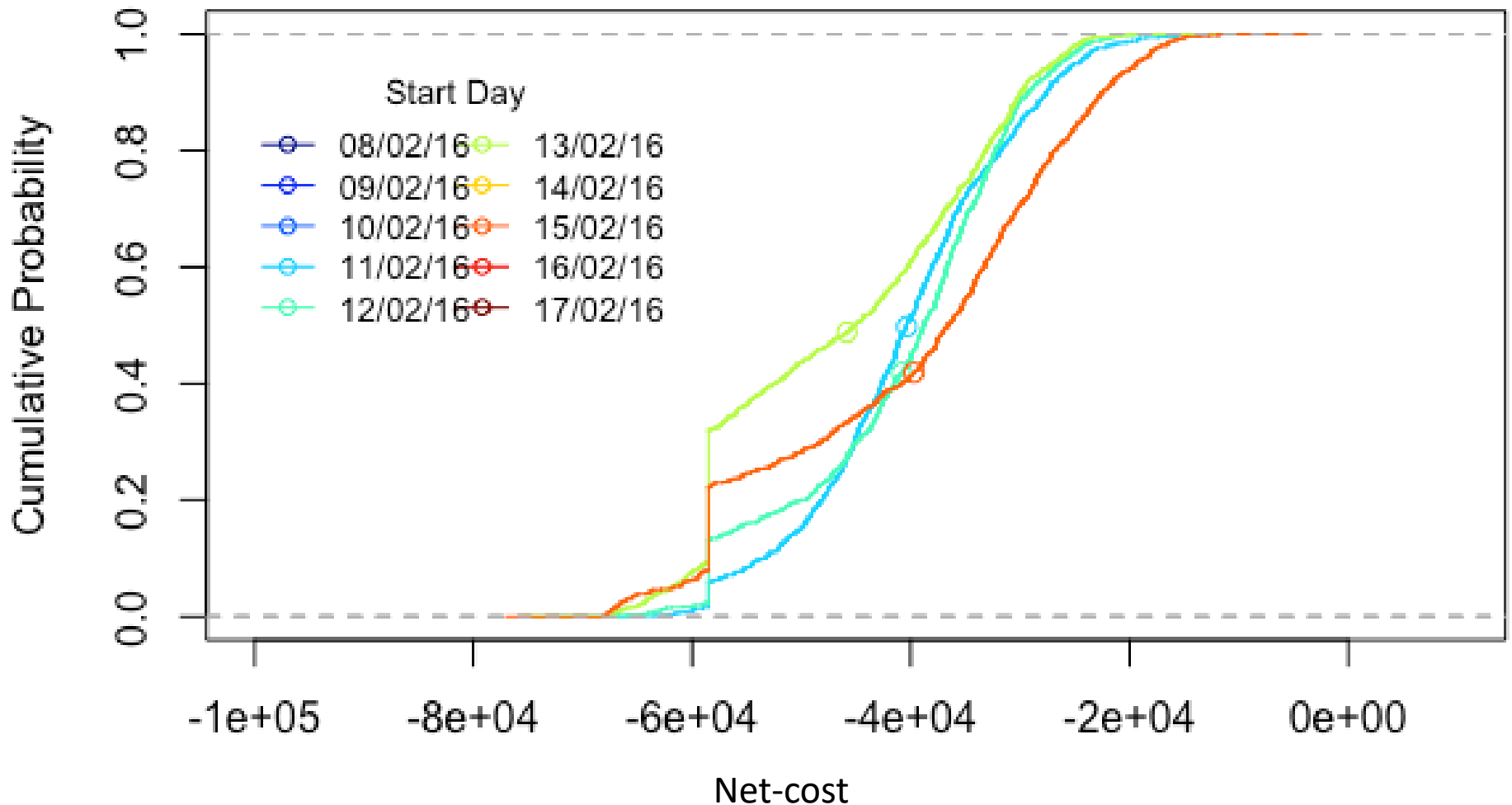
Distribution of net-cost



Outputs

Schedule

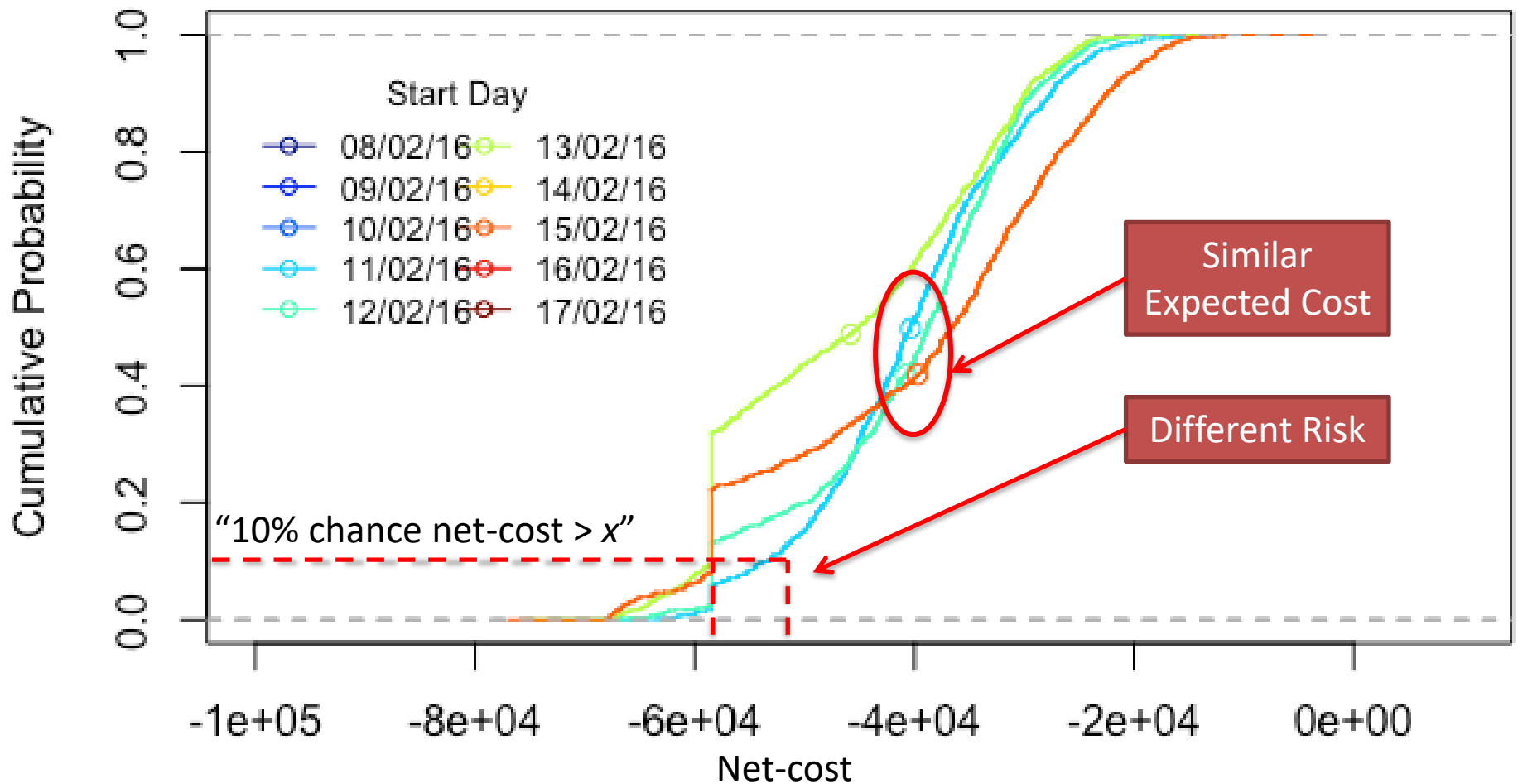
Comparing Options



Outputs

Schedule

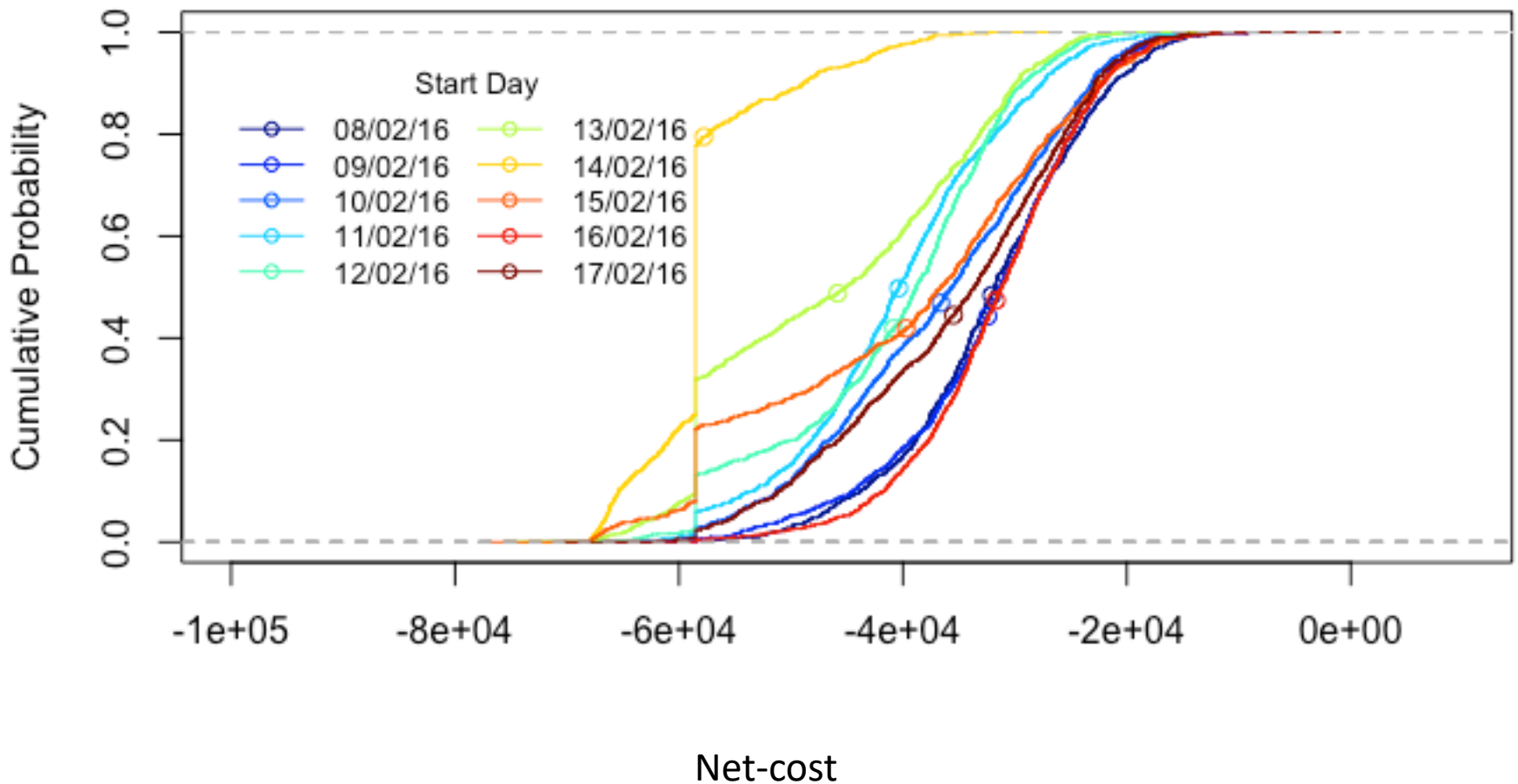
Comparing Options



Outputs

Schedule

Comparing Options



Outputs

Schedule

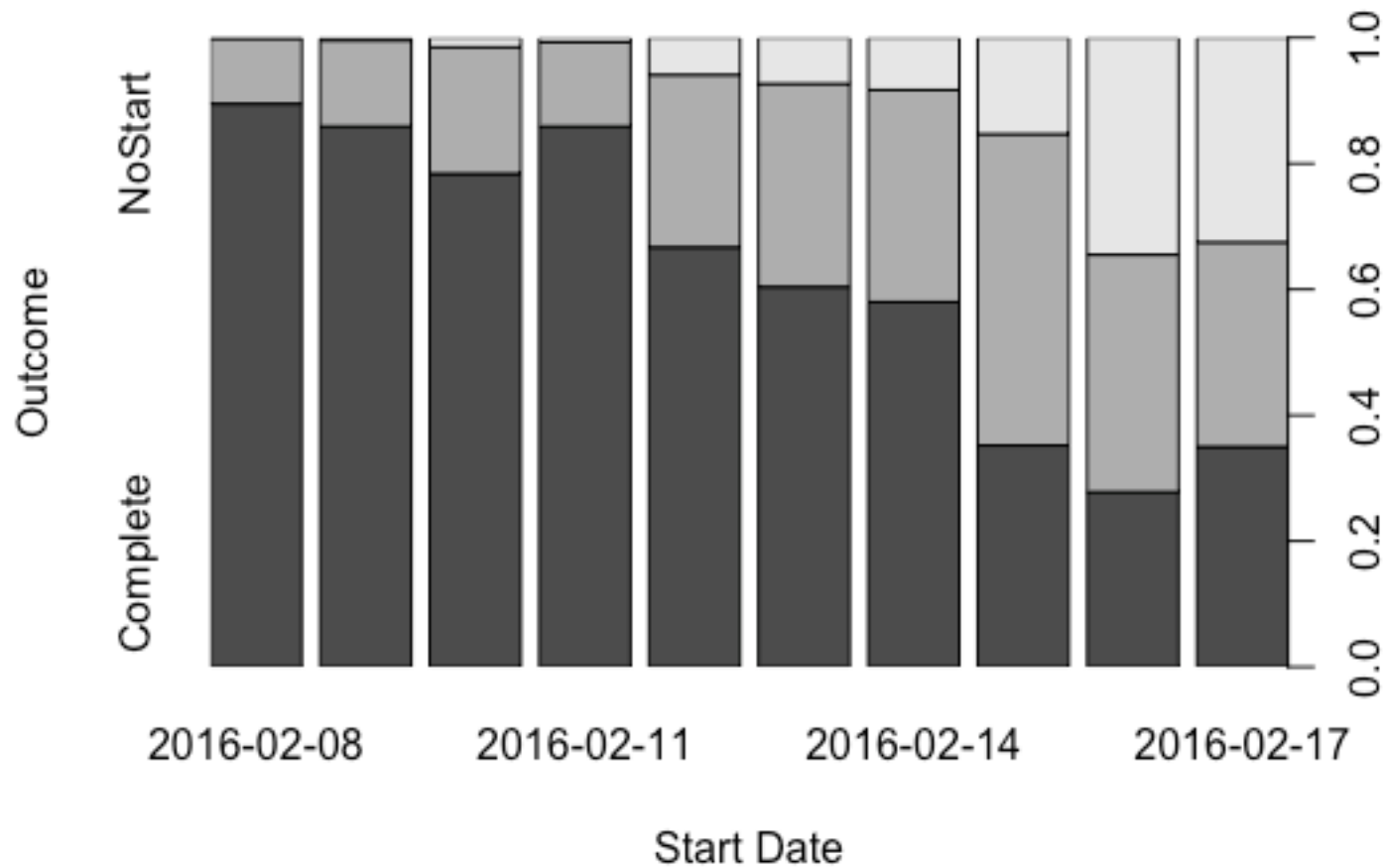
Comparing Options

Date	Expected Cost	10% Risk
11/02/16	£ 40k	£ 55k
12/02/16	£ 40k	£ 60k
15/02/16	£ 40k	£ 60k

Outputs

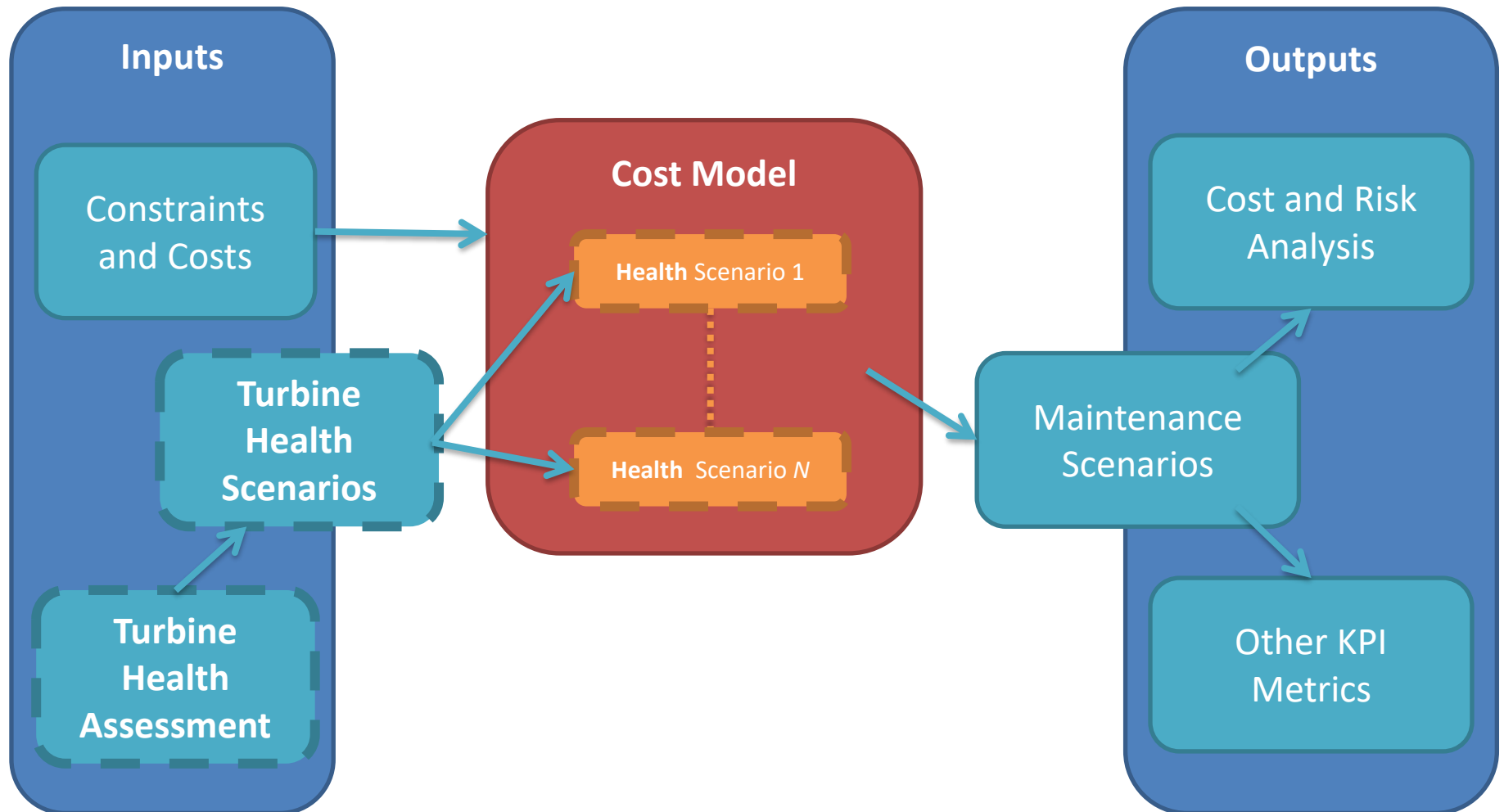
Go/No-Go

Comparing Options: Classification

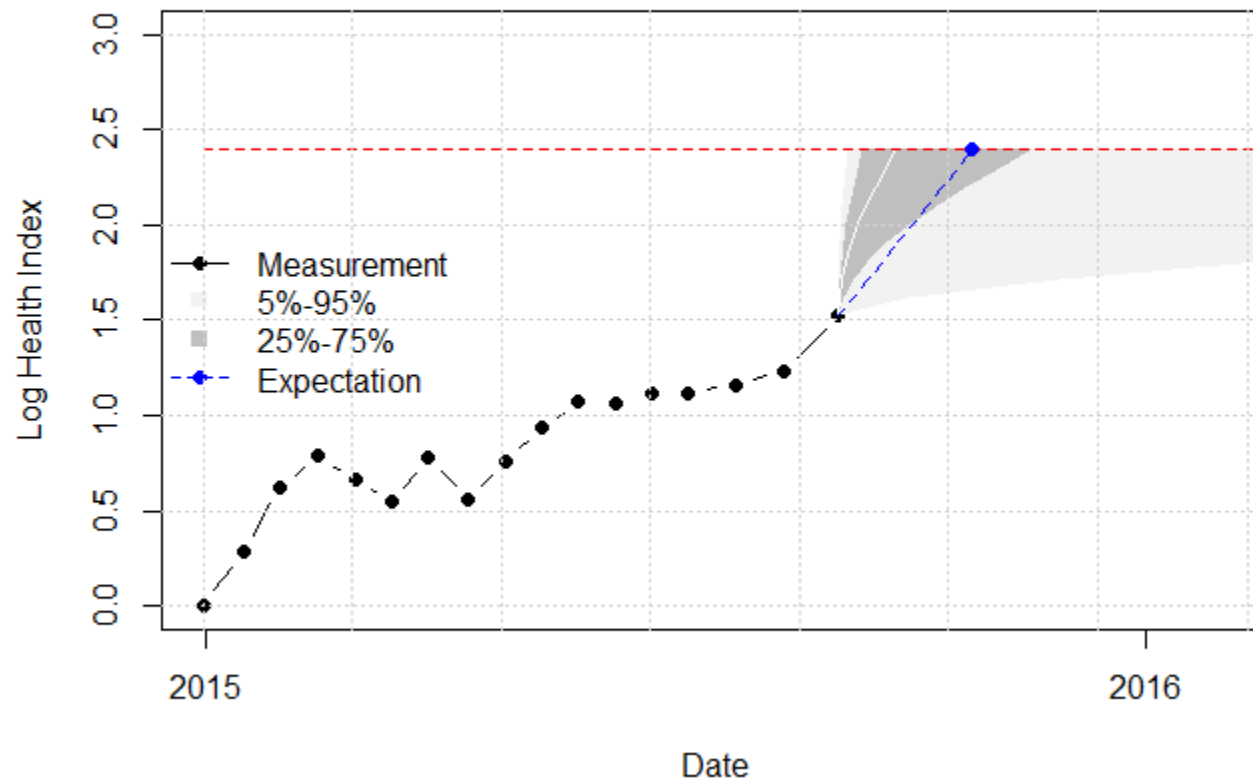


Next Steps?

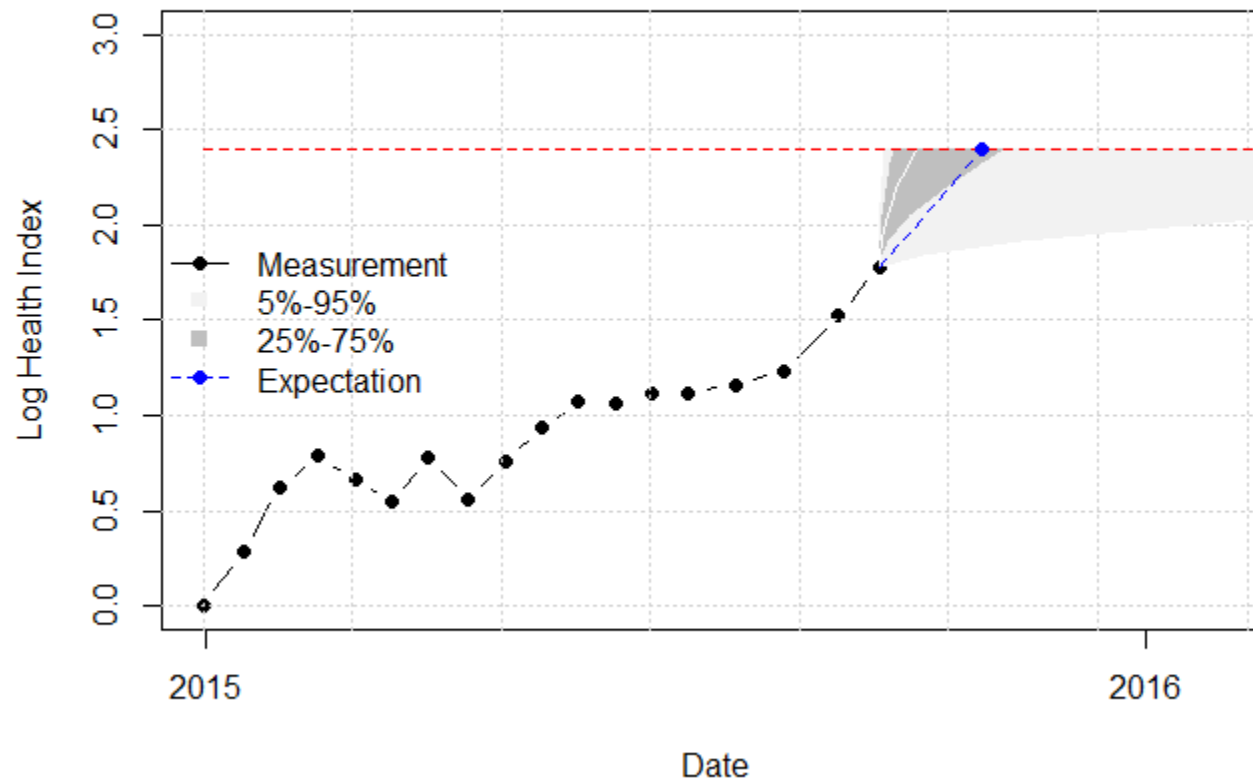
Condition-based Maintenance



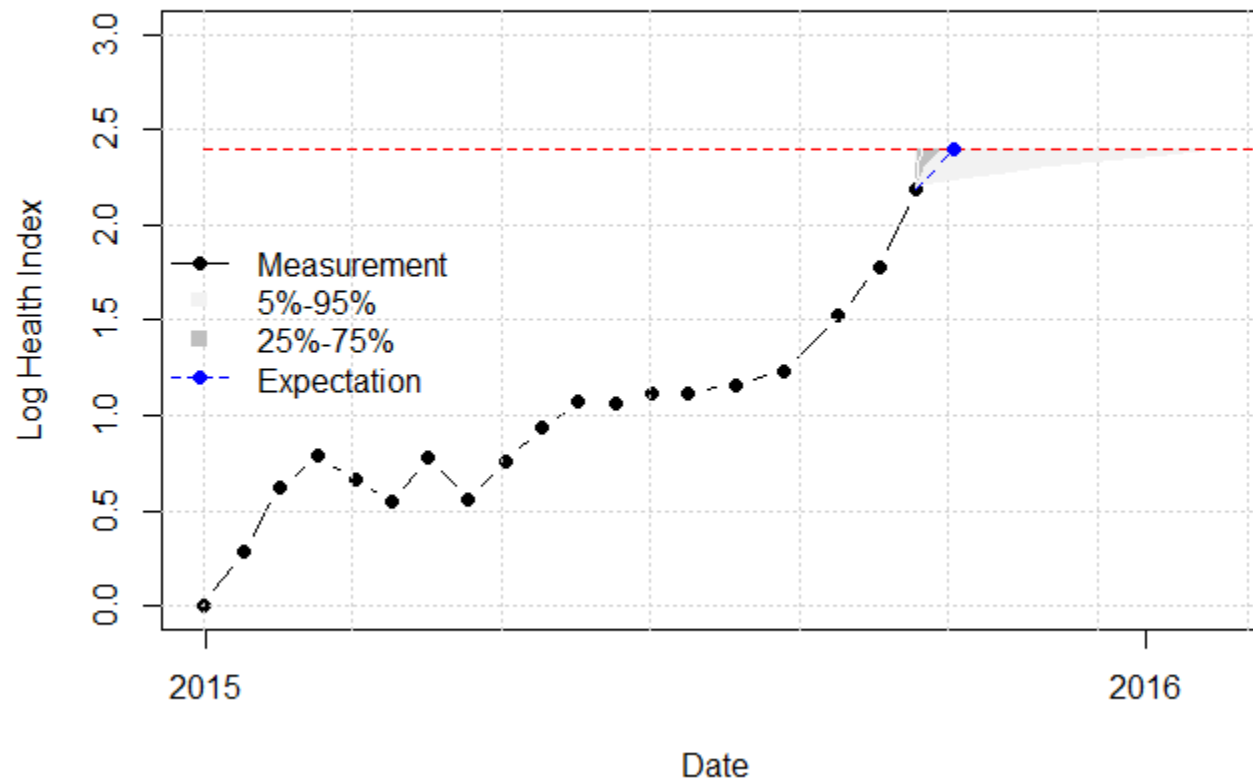
Degradation Model



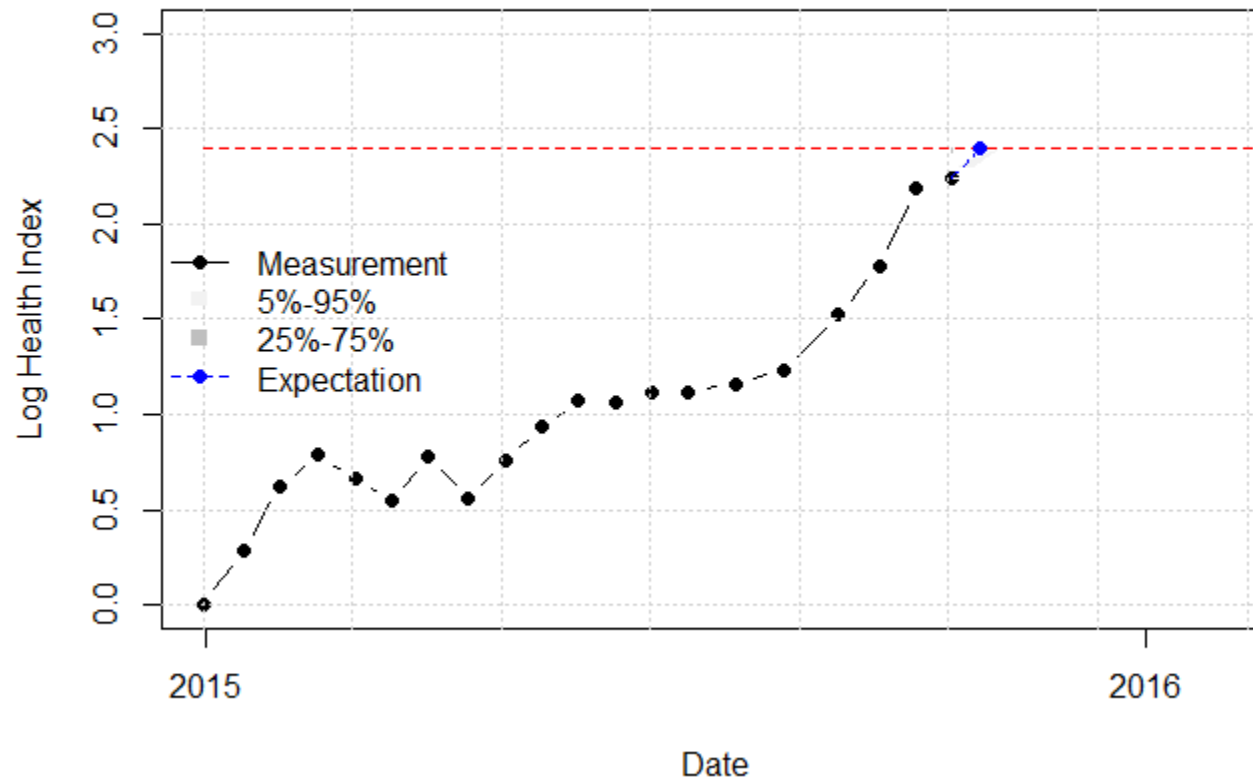
Degradation Model



Degradation Model



Degradation Model



Questions





University of
Strathclyde
Glasgow