Welcome

WIND . ASSURING CONFIDENCE
THROUGH COMPETENCE

Assessment of effects of adverse weather conditions on offshore projects

QUALITY SYSTEM CERTIFICATION
DNV·GL
ISO 9001

Gerrit Wolken-Möhlmann
Dr. Marcel Wiggert

ForWind Zentrum für Windenergieforschung Bremen Hannover Oldenburg

Fraunhofer IWES

Agenda & Goals

- **Introduction to weather risks**
- **COAST concept**
- **Case study**
- **Summary and outlook**

Goals:

- Introduction to a holistic approach to analyze Transport and Installation (T&I) strategies using long weather time series
- Case study for different locations and a downtime map
- Where to apply the analysis method and principles how to reduce your weather risks

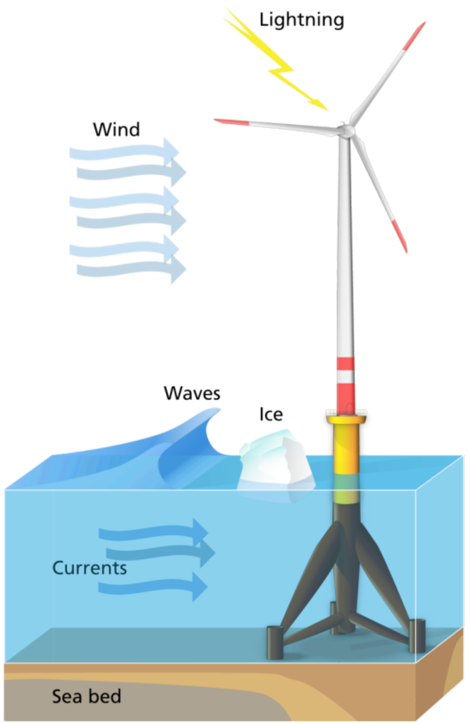

Figure: Florian Meier

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Weather Risks
Offshore Wind Projects

Example: Project Delays

- 2001 Middelgrunden
- 2004 Scroby Sands
- 2009 Horns Rev 2
- 2009 Alpha Ventus “*Weather conditions delay construction work at sea*”
- 2010 Robin Rigg
- 2011 Bard Offshore 1
- 2012 “*London Array delay costs Dong millions*”
- 2012 Greater Gabbard “where weather problems contributed to a $400m loss”
- 2012 “*Bad weather causes delay to Sheringham Shore windfarm project*”
- 2012 “*DONG Fights Weather Condition During Anhold Wind Turbine Installation*”
- 2013 Meerwind Ost
- 2014 Amrumbank West

Example: Positive Effects

- 2010 Thanet
- 2012 Alpha Ventus (energy yield)

Risk Optimization = Cost Reduction

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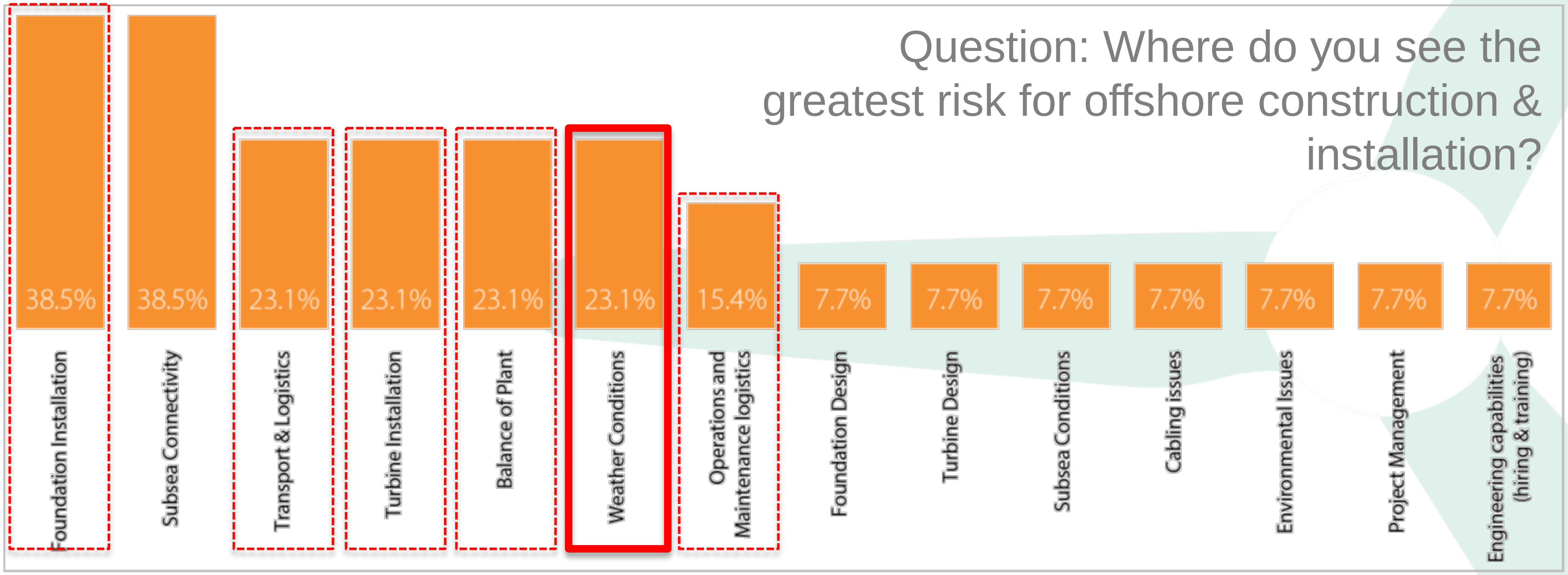
Wind Energy Update's - Market Survey 2015 Offshore Wind Construction and Installation



General comment of a participant:
"Purely financially speaking: weather risk management solutions to make budgets workable and stable"

(300+ participants)

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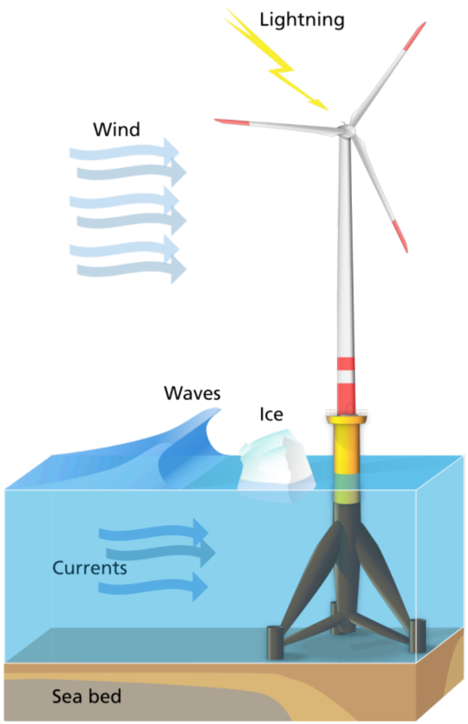

Figure: Florian Meier

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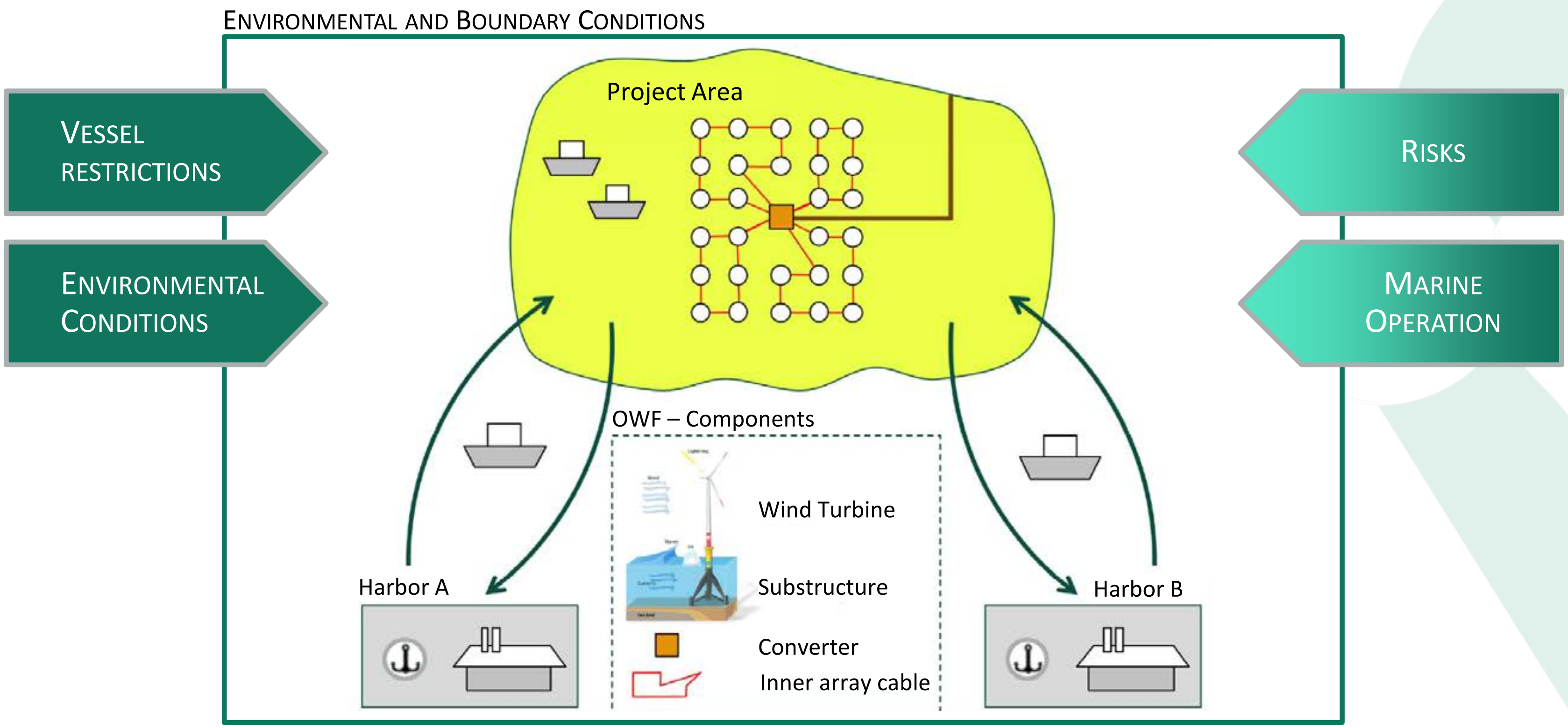
Offshore Wind Farm
Setting the Scene



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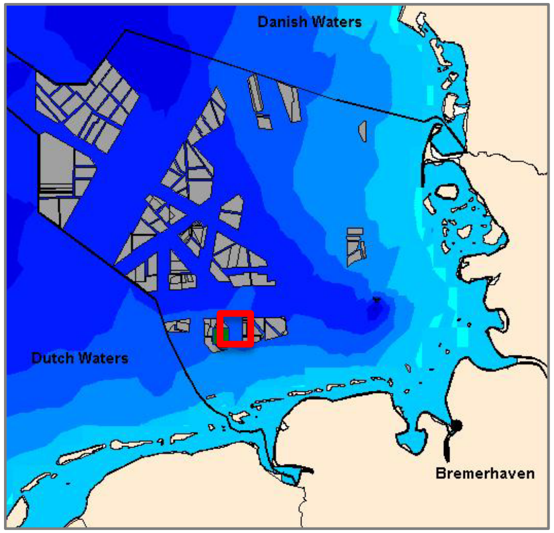
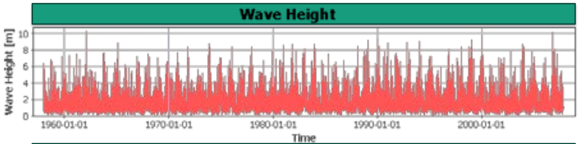
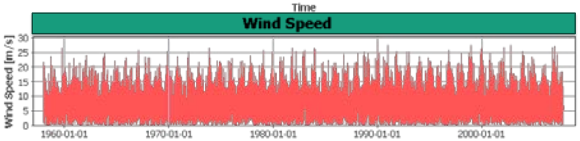
Wind Farms and Local Weather Conditions







- Location:
  - E.g. Fraunhofer Virtual Reference Wind Farm
- Local weather conditions:
  - Waves (e.g.: significant waves height, peak period, …)
  - Wind (e.g.: speed, gusts, …)
  - Currents, Temperature, Visibility, Clouds, Daylight, …
- Weather Data: (Example)
  - HZG CoastDat v1 (Helmholz Zentrum Geesthacht)
  - Time period: 1958 – 2007

Individual Vessel Strategy and Project Schedule

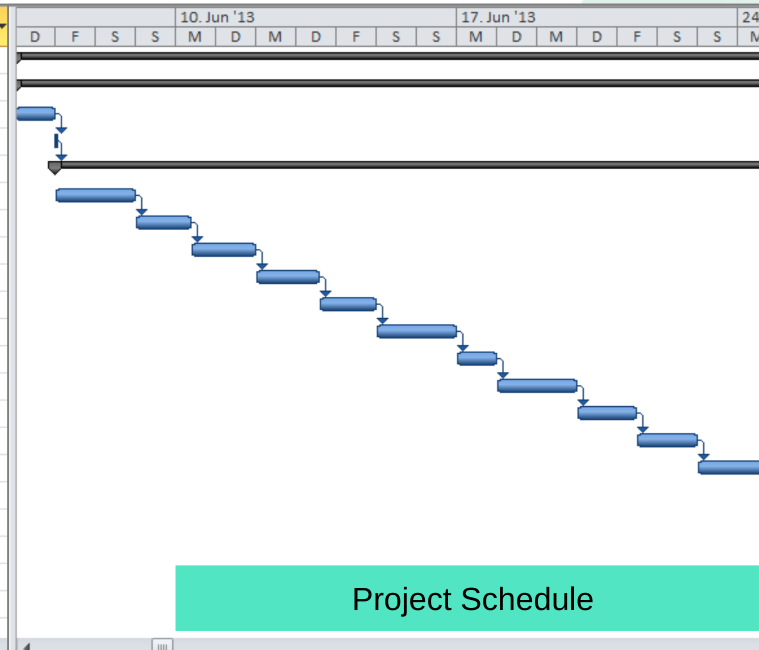
Installation Strategy

Vessel concept

www.hochtief.de

- H_S = 2,5m; U = 15m/s
- Costs: 250.000 €/d
- Expensiv, lower weather risk

	Vorgangsname	Anfang
1	**Project 12WTs**	**Do 06.06.13**
2	**Installation of pin pil**	**Do 06.06.13**
3	port activities	Do 06.06.13
4	outbound trip	Do 06.06.13
5	**drive 48 piles**	**Fr 07.06.13**
6	drive 4 piles	Fr 07.06.13
7	drive 4 piles	Sa 08.06.13
8	drive 4 piles	Mo 10.06.13
9	drive 4 piles	Mi 12.06.13
10	drive 4 piles	Do 13.06.13
11	drive 4 piles	Sa 15.06.13
12	drive 4 piles	So 16.06.13
13	drive 4 piles	Di 18.06.13
14	drive 4 piles	Mi 19.06.13
15	drive 4 piles	Fr 21.06.13
16	drive 4 piles	So 23.06.13
17	drive 4 piles	Mo 24.06.13
18	inbound trip	Mi 26.06.13
19	**Installation of jacket**	**Mi 26.06.13**
20	port activities	Mi 26.06.13
21	outbound trip	Do 27.06.13
22	**installation of 3 ja**	**Do 27.06.13**



Project Schedule

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Information Profile

Weather Conditions

Weather Parameters

- Local weather conditions, e.g.
  - Significant wave heights
  - Wind speeds
  - Currents
  - Temperature
  - Visibility

Weather Time Series

Measured | Hindcast

T&I Concept

Project Schedules

- Required T&I processes and sequences
- Project overall project time schedule

Project Schedules

Installation Strategy

- Design of the structure
- Location wind farm/ ports
- Vessel and equipment concept
- Guideline requirements
- Contractual agreements

Boundary Conditions

Restrictions | Guidelines

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Weather Time Series

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Forecast

Project Duration

Weather Risk Profile

Sensitivity and Scenario Analysis

Robust Project Schedules

Cost and Risk optimization

Information Profile

WEATHER CONDITIONS

WEATHER PARAMETERS

- Local weather conditions, e.g.
  - Significant wave heights
  - Wind speeds
  - Currents
  - Temperature
  - Visibility

WEATHER TIME SERIES

MEASURED | HINDCAST

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RESTRICTIONS | GUIDELINES

FORECAST

PROJECT DURATION

WEATHER RISK PROFILE

Sensitivity and Scenario Analysis

ROBUST PROJECT SCHEDULES

COST AND RISK OPTIMIZATION

CONTINUOUS ANALYSIS PROCESS → EASY WORK FLOW INTEGRATION

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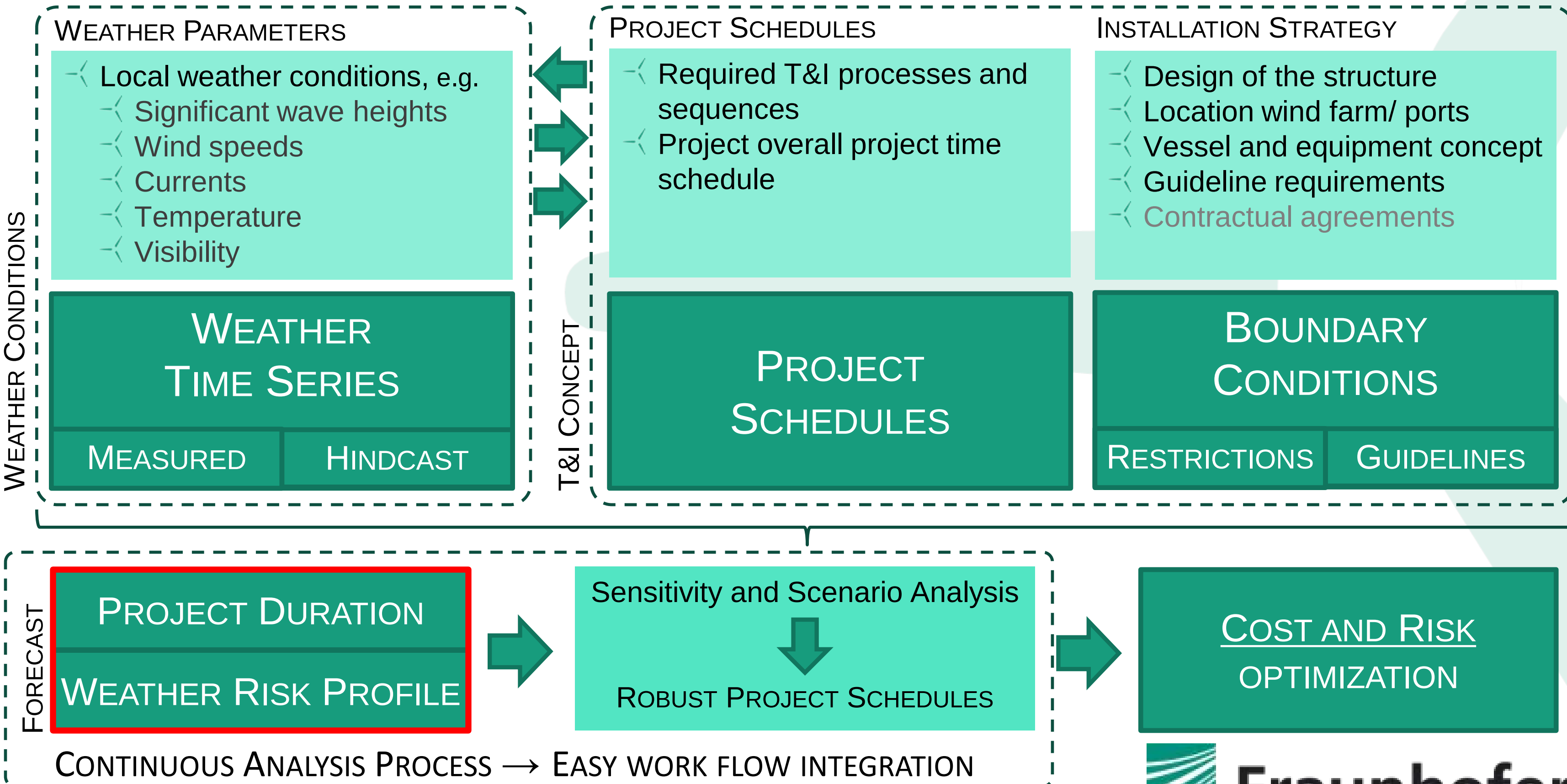
Information Profile



COAST – Research Project
Comprehensive Offshore Analysis and Simulation Tool

Munich RE

HOCHTIEF SOLUTIONS AG

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Deutscher Wetterdienst
Wetter und Klima aus einer Hand
DWD

BUGSIER www.bugsier.de

WindMW

Supported by:

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

based on a decision of the Parliament of the Federal Republic of Germany

Source: shutterstock

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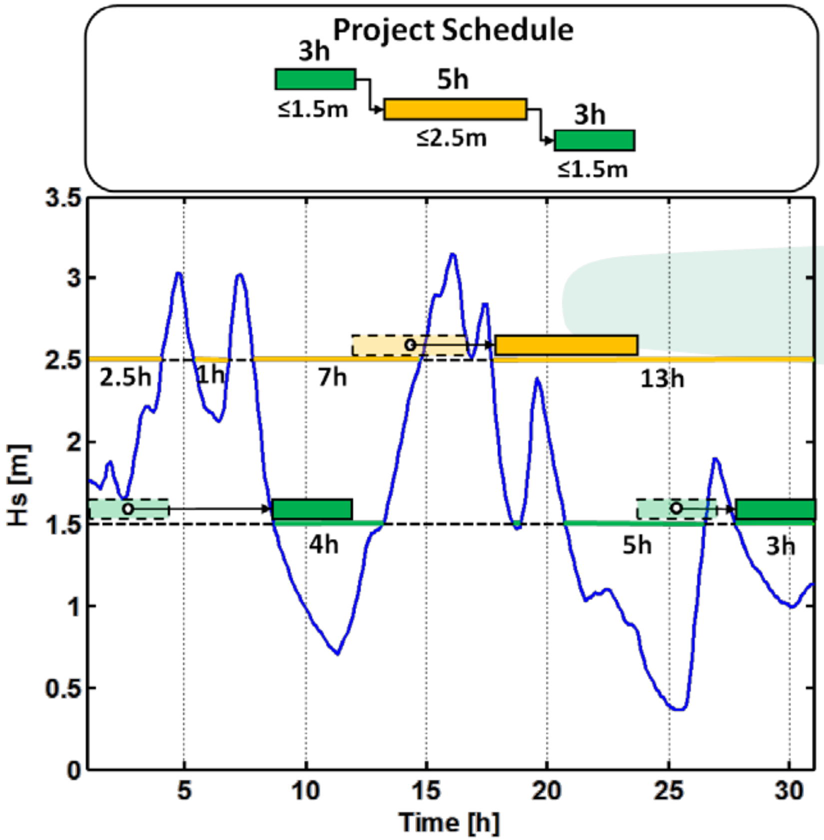
WaTTS – Method
Weather Time Series Scheduling



- Consideration of:
  - Task sequence
  - Contingencies in guidelines
  - Different weather restrictions
  - Weather forecast error
- Calculation of project durations and their probabilities
- Calculation of installation cycles

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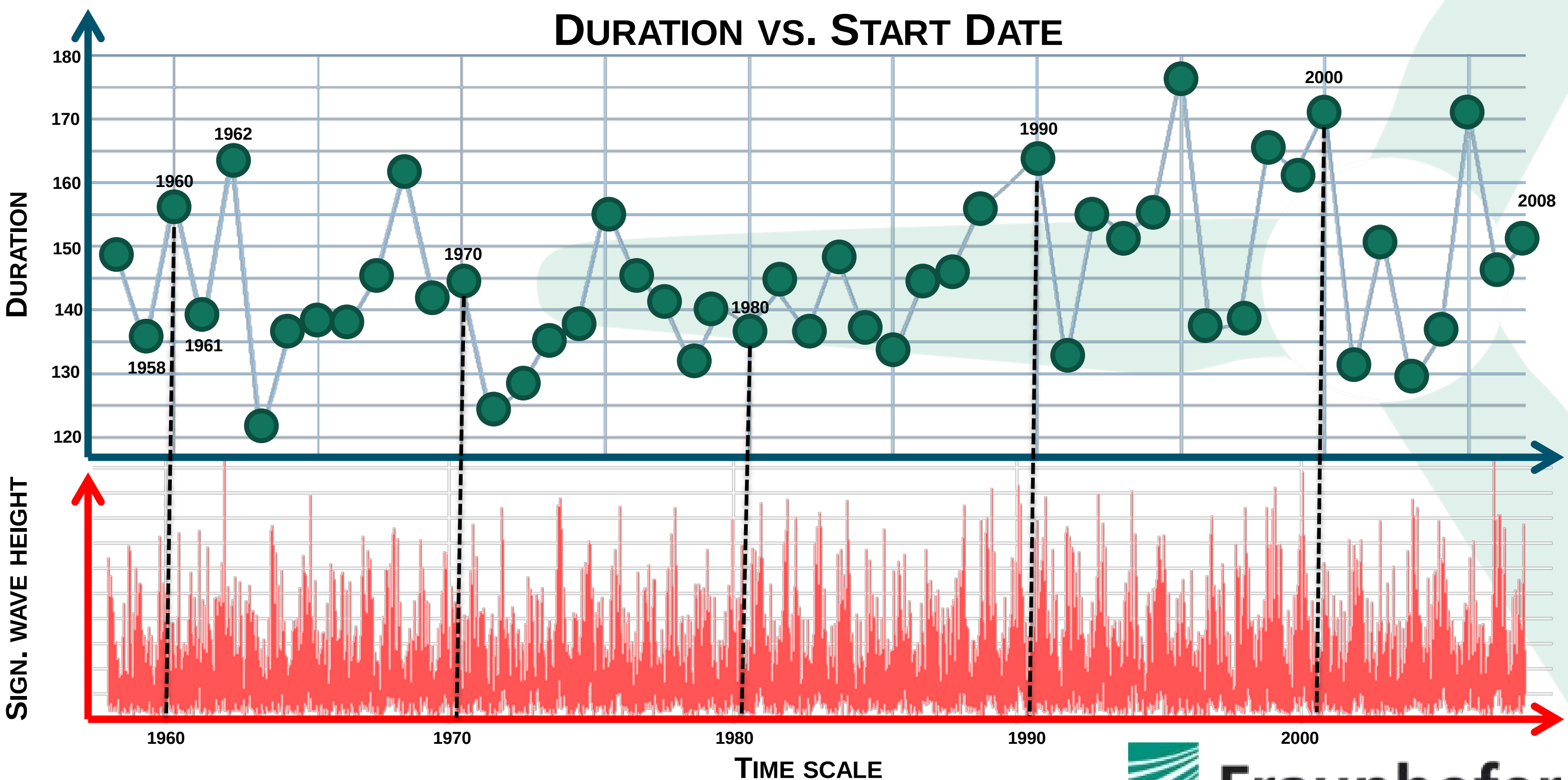
Principle of Yearly Simulation



Start Date: e.g. 01.01.

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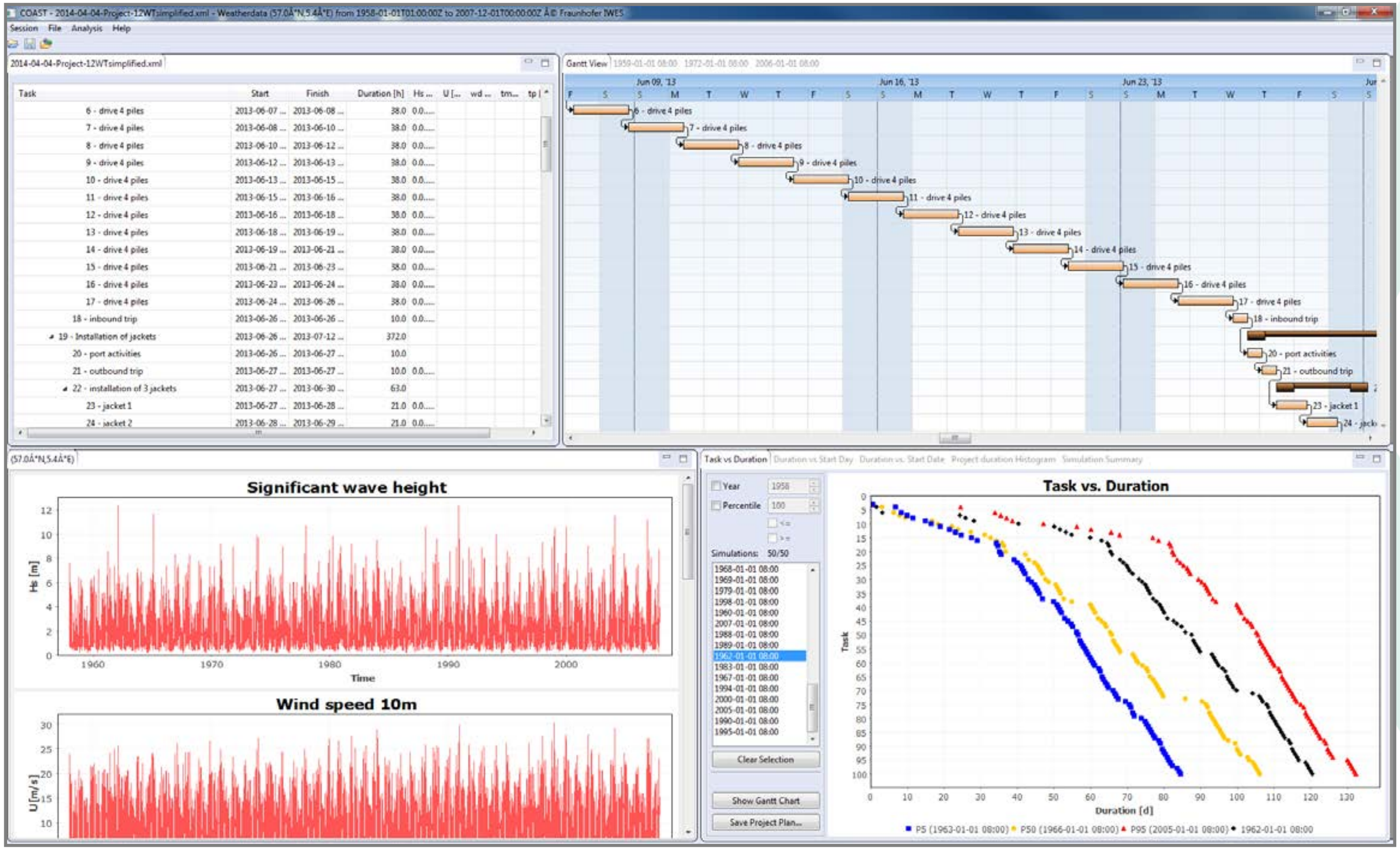
COAST - Software



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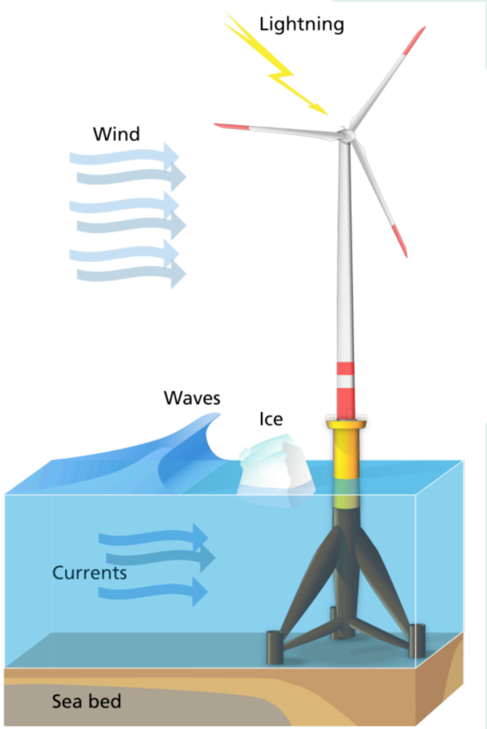

Figure: Florian Meier

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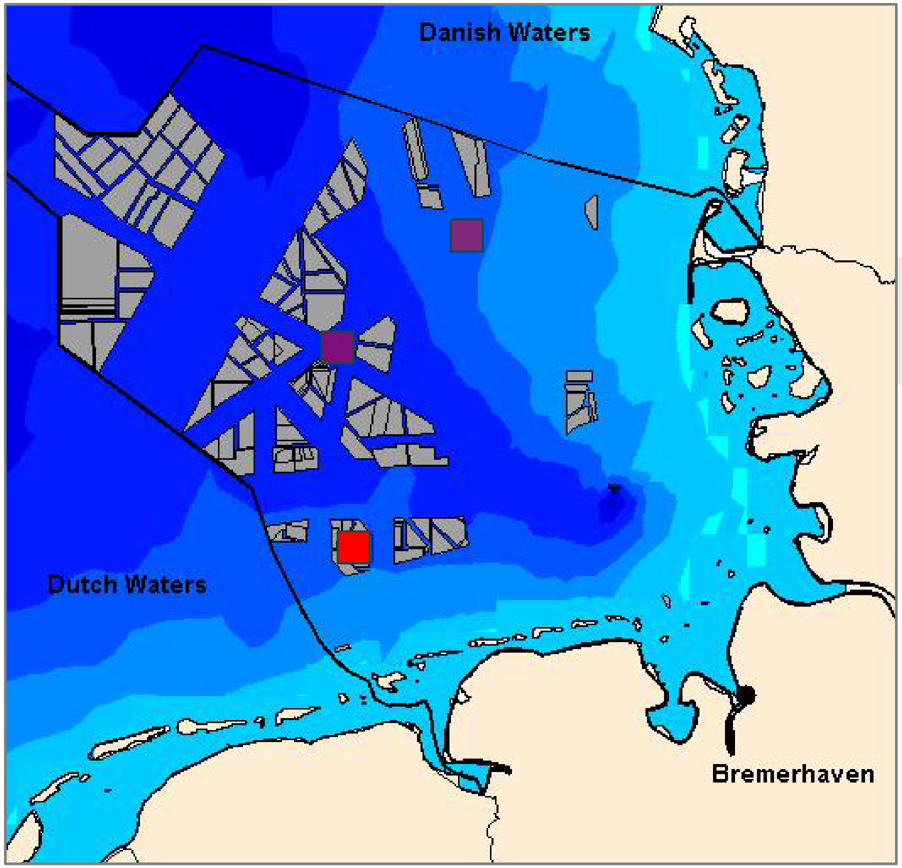
Virtual Reference Wind Farms

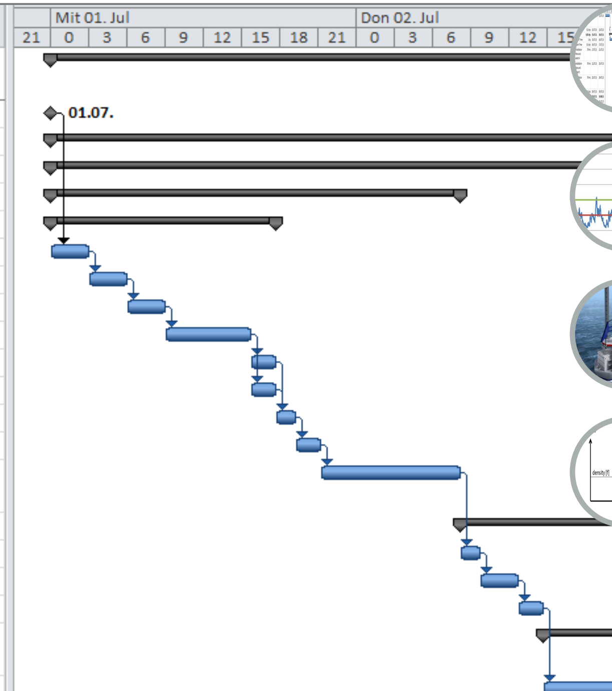


- Location:
  - **FINO1 (54,0°N 6,6°E)**
  - FINO3 (55,2°N 7,2°E)
  - NSBIII (54,7°N 6,8°E)
- Weather Data:
  - Approx. Alpha Ventus
  - HZG CoastDat v1
    (Helmholz Zentrum Geesthacht)
  - Time period: 1958 – 2007
  - Weather Parameters (used)
    - Significant Wave Height (h_S)
    - Wind speed (U)

Case Study:
Installation Sequence

Repetitive Operational Sequence

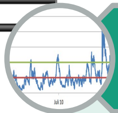
	Vorgangsname	Anfang	Fertig stellen
1	**Installation of 20 Foundations, cable works and WTG**	**Mi 01.07.15**	**Mo 03.07.17**
2	Start of Project	Mi 01.07.15	Mi 01.07.15
3	**Installation of Foundations**	**Mi 01.07.15**	**Mi 24.05.17**
4	**Loop 1: Foundation 01 -10**	**Mi 01.07.15**	**Di 02.05.17**
5	**1. Load of at Baseport**	**Mi 01.07.15**	**Do 02.07.15**
6	**LoadOut of 3 sets at Port**	**Mi 01.07.15**	**Mi 01.07.15**
7	Loading Foundation 01	Mi 01.07.15	Mi 01.07.15
8	Loading Foundation 02	Mi 01.07.15	Mi 01.07.15
9	Loading Foundation 03	Mi 01.07.15	Mi 01.07.15
10	Loading 9 piles	Mi 01.07.15	Mi 01.07.15
11	Loading Grout Materials	Mi 01.07.15	Mi 01.07.15
12	Seafastening	Mi 01.07.15	Mi 01.07.15
13	Jack DOWN	Mi 01.07.15	Mi 01.07.15
14	Port Departure Procedures	Mi 01.07.15	Mi 01.07.15
15	Travel to Offshore Site [100NM@10kn+1h]	Mi 01.07.15	Do 02.07.15
16	**Foundation 01 Installation by HLJV**	**Do 02.07.15**	**Di 11.04.17**
17	Jack UP	Do 02.07.15	Do 02.07.15
18	Preloading	Do 02.07.15	Do 02.07.15
19	Preparation works	Do 02.07.15	Do 02.07.15
20	**Foundation Installation to Seabed**	**Do 02.07.15**	**Mo 10.04.17**
21	Lift Foundation onto seabed	Do 02.07.15	Mo 10.04.17



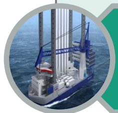
Input Data:

20 Jacket

> 1.400 Activities

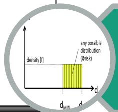


No Guidelines considered



Sign. Wave Height

Wind Speed



Start Date:

Continues Simulation

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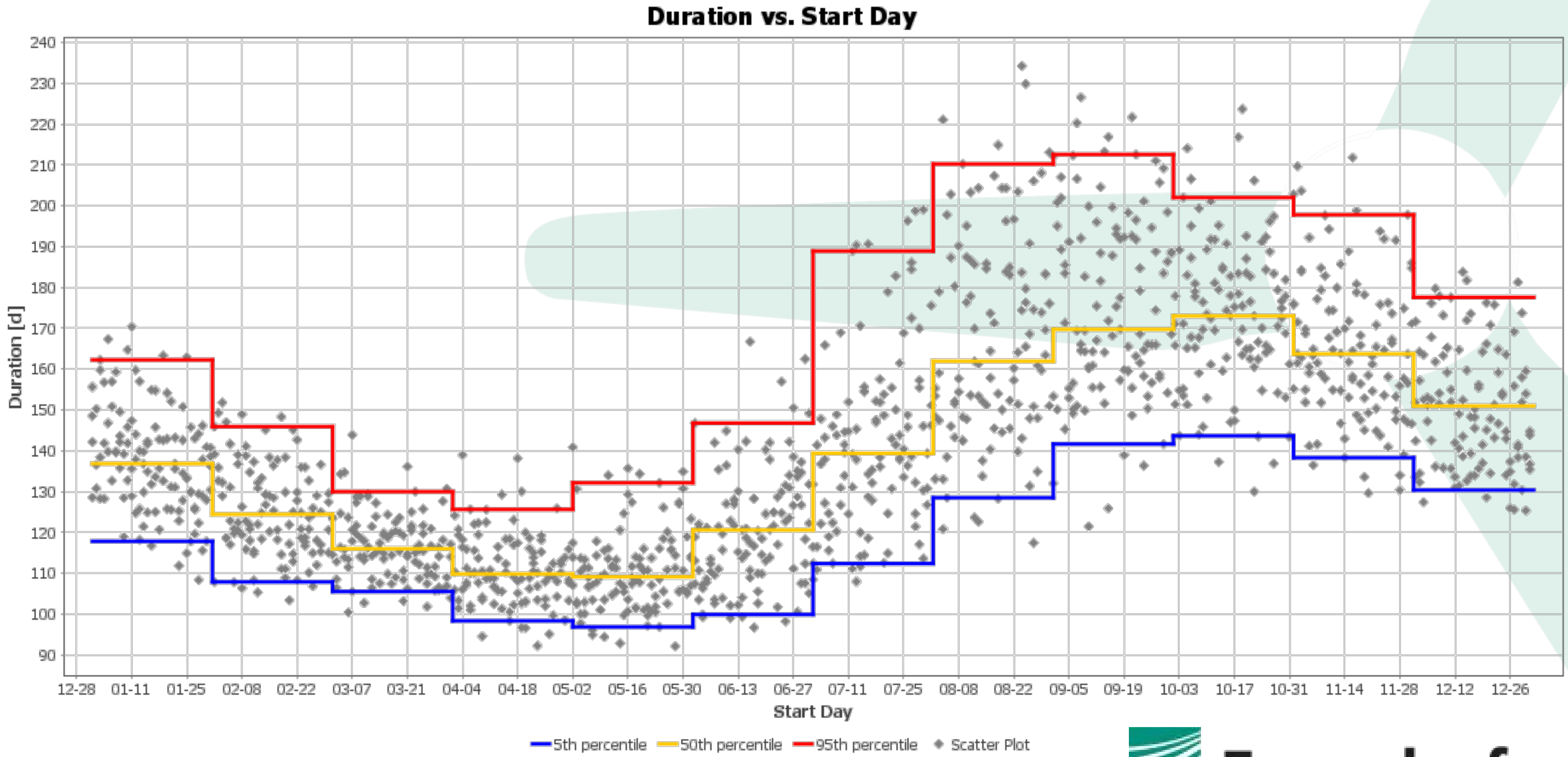
Case Study:
Result FINO1 – Duration vs. Start Day



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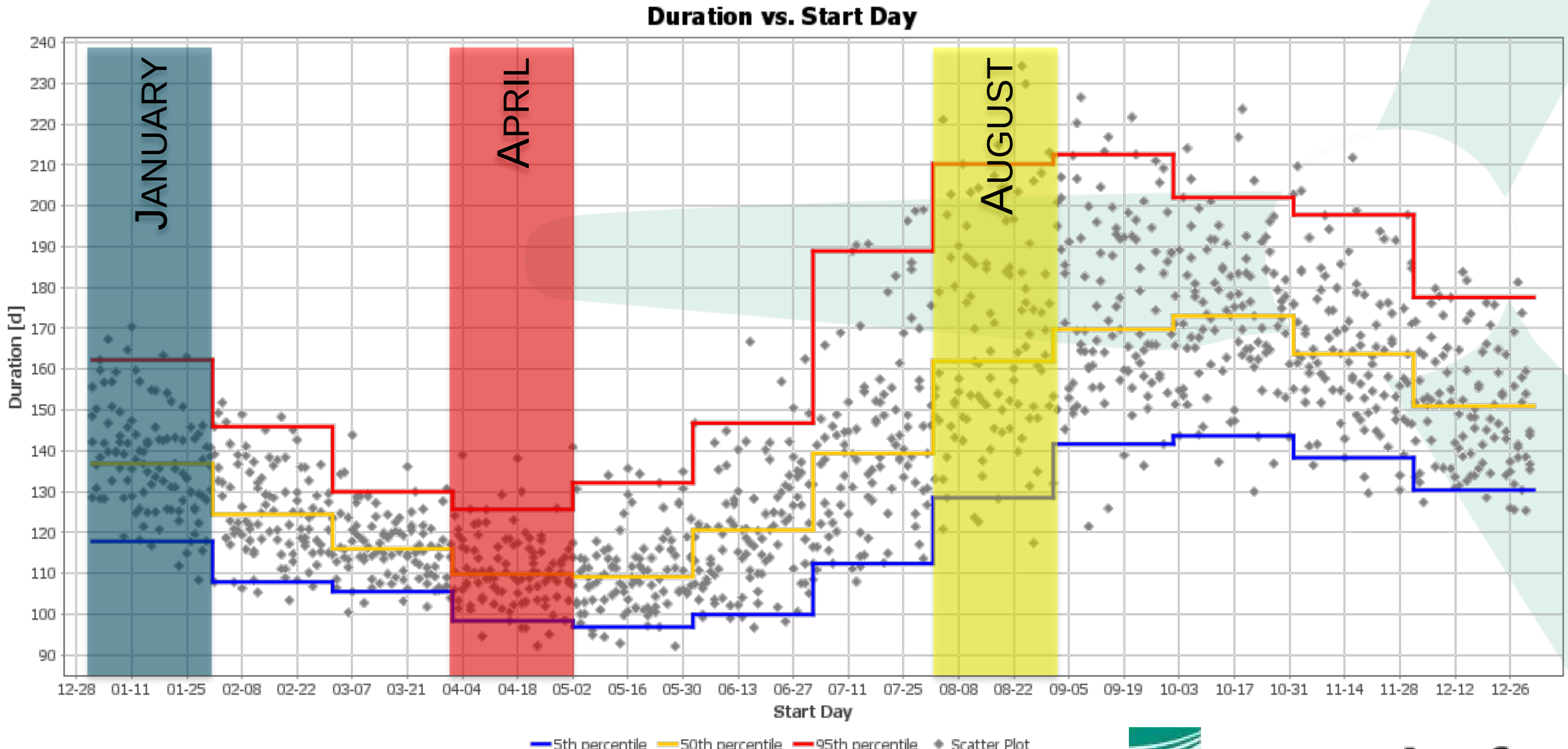
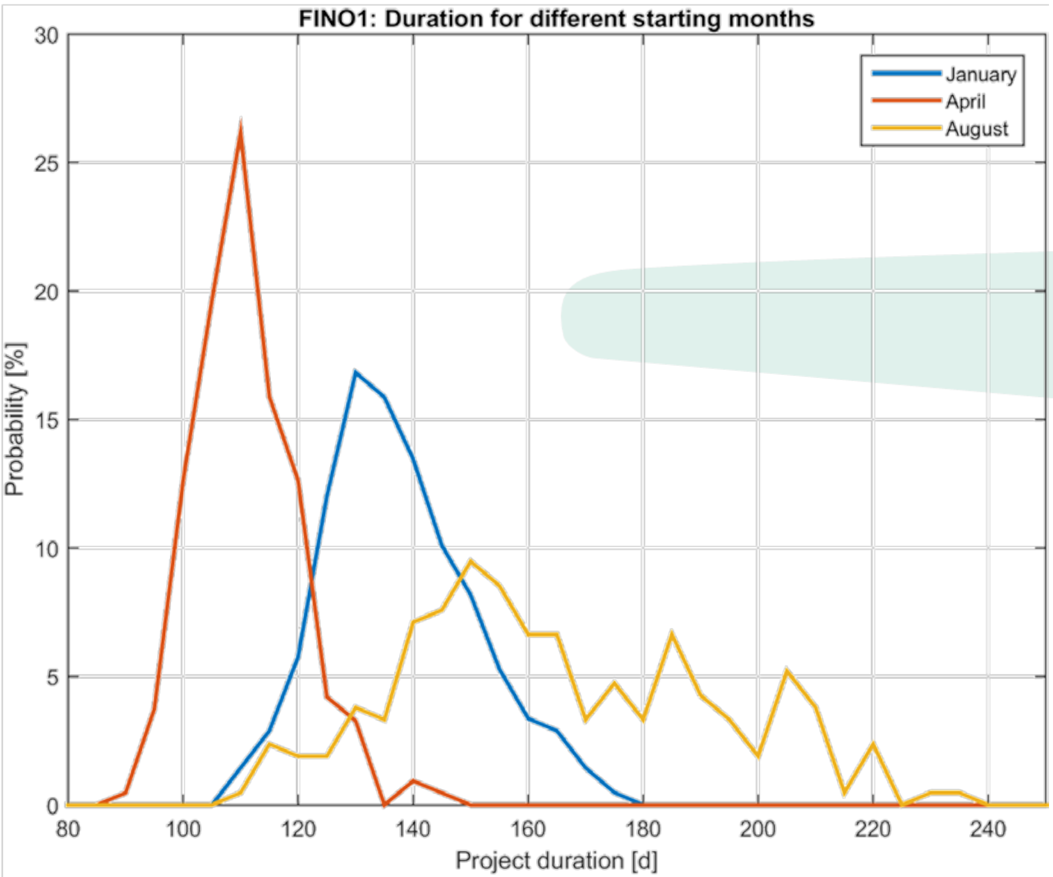


Case Study:
Result FINO1 – Distribution Comparison



- Primary weather risk
- Secondary weather risk

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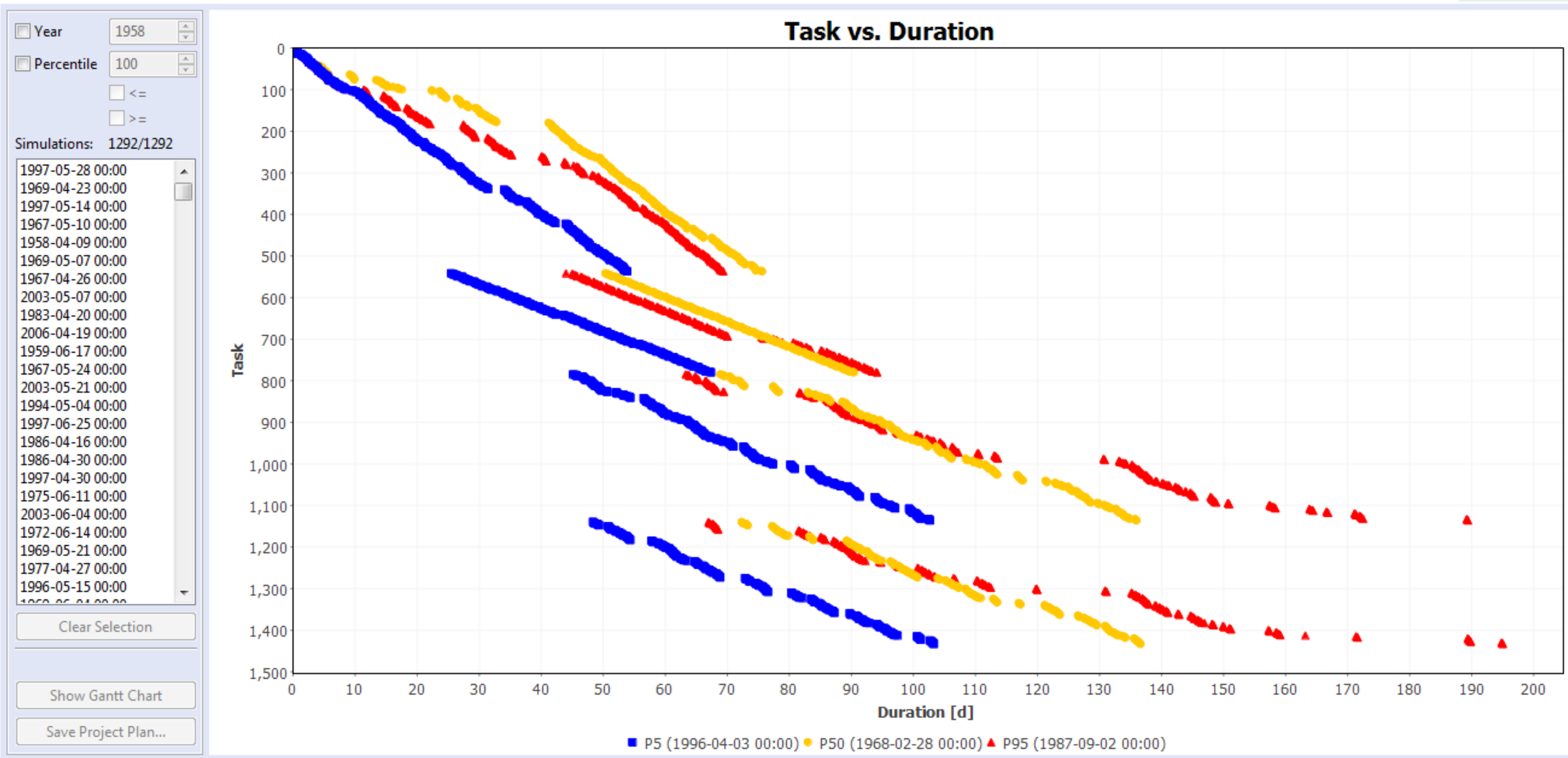
Case Study:
Result FINO1 – Task vs. Duration



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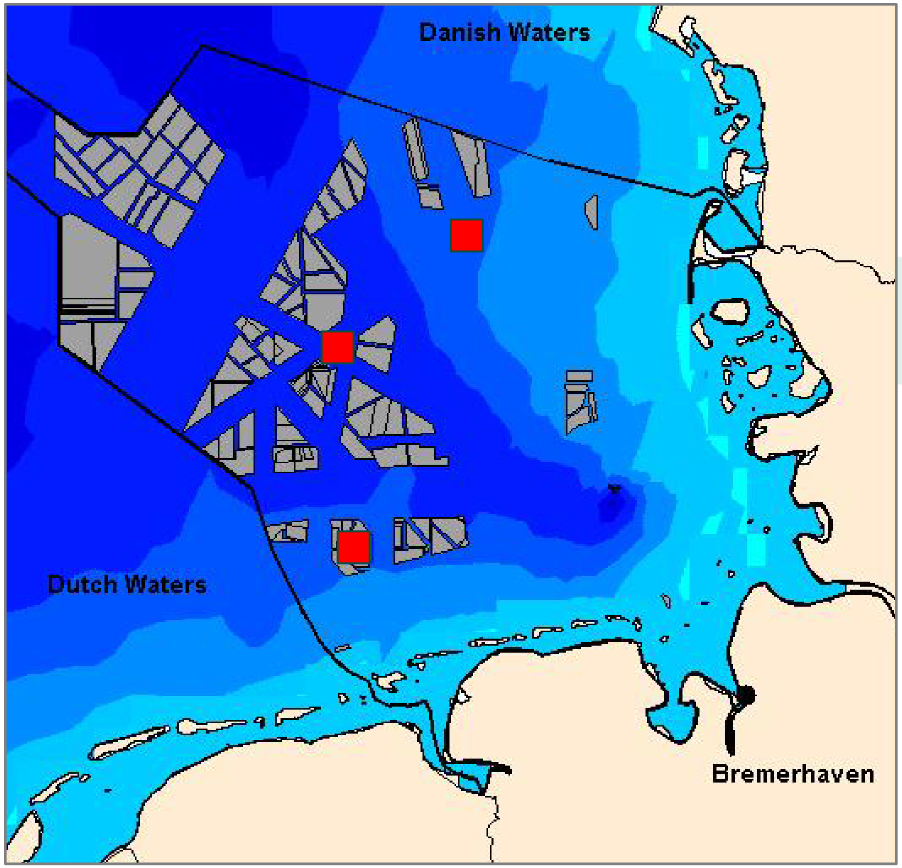

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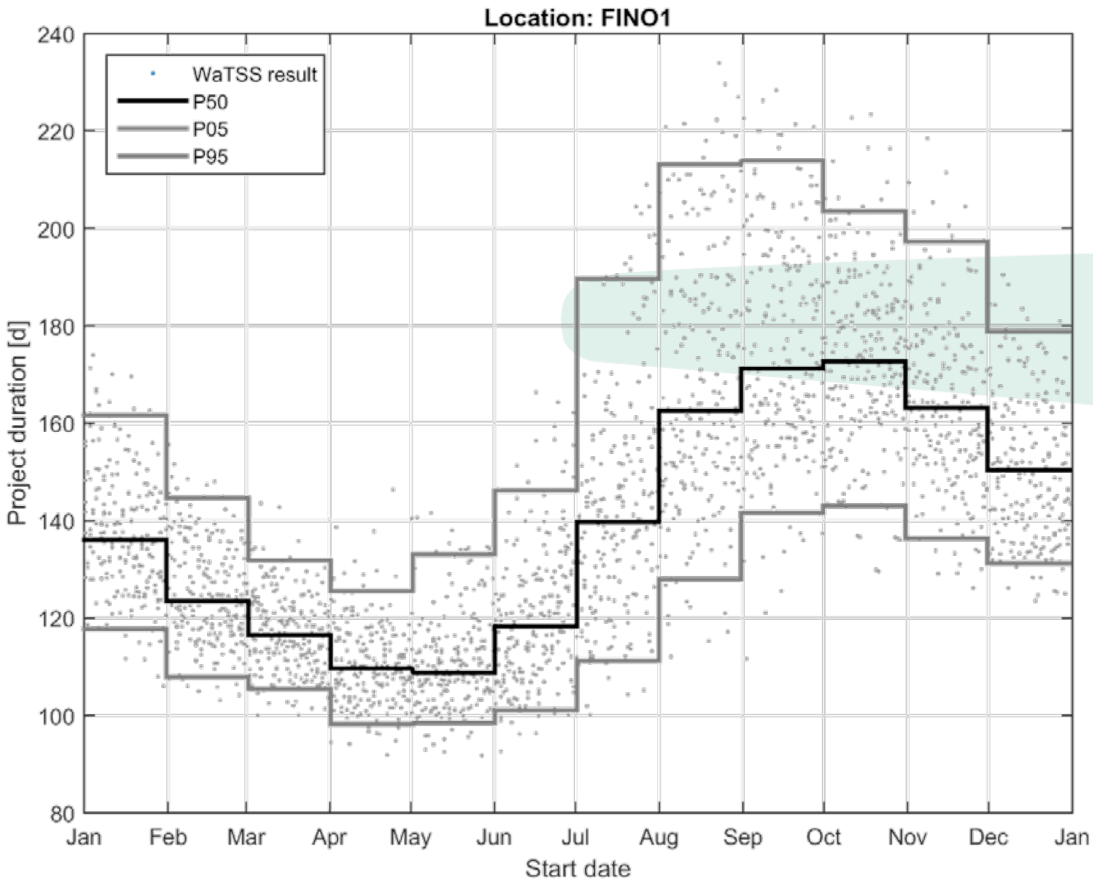
Comparison of Different Locations



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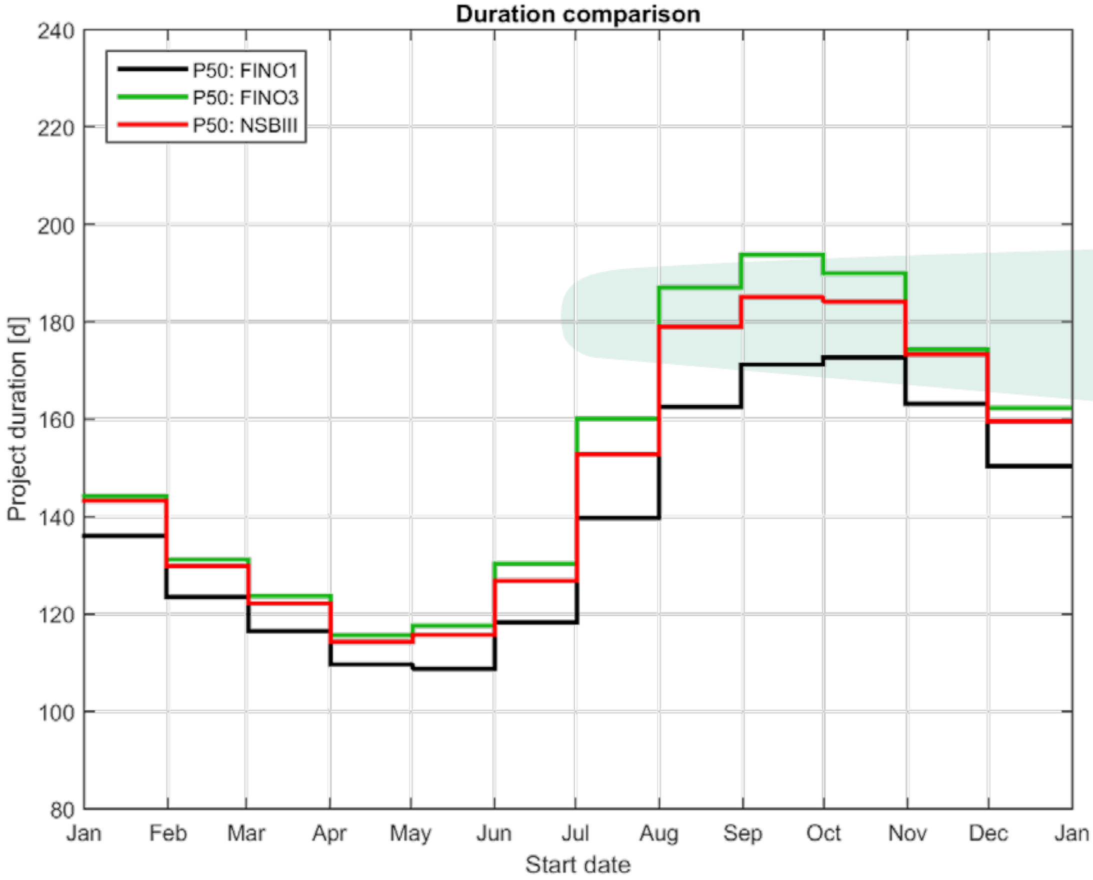

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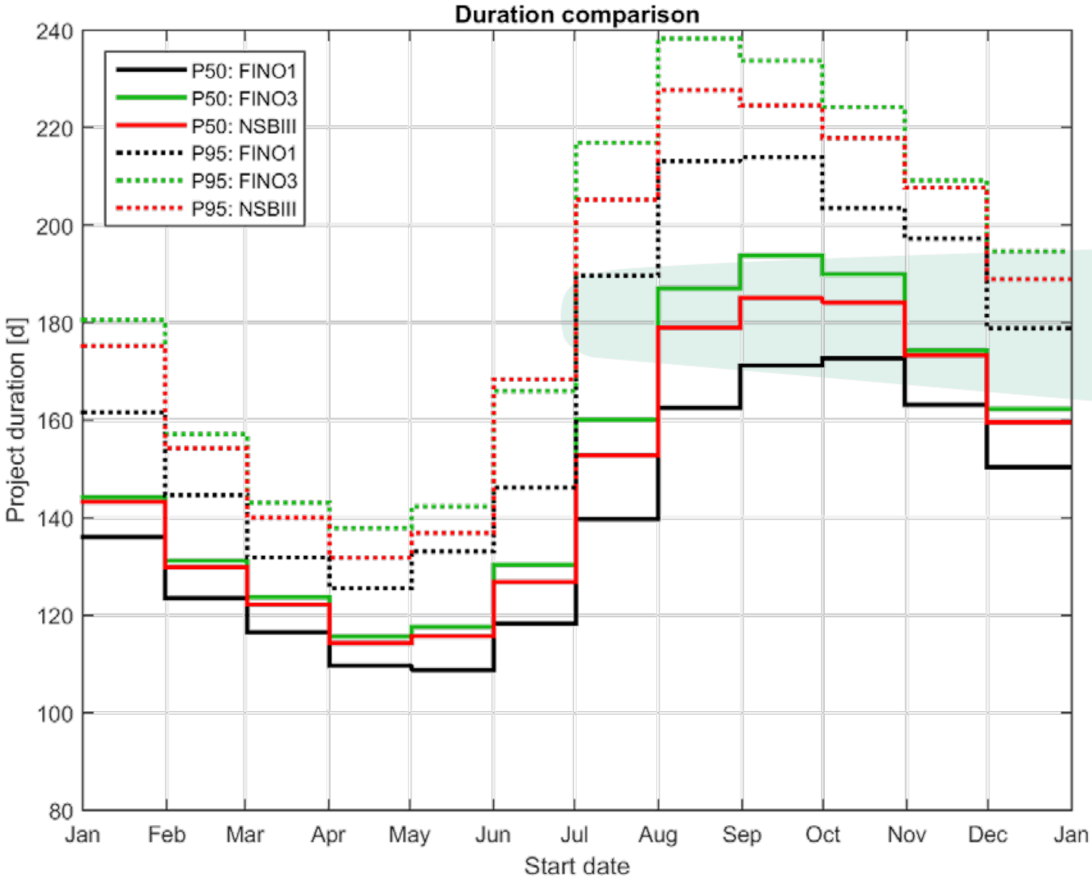

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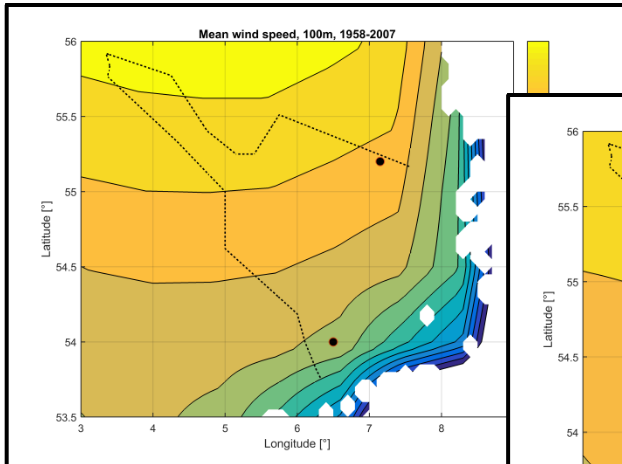
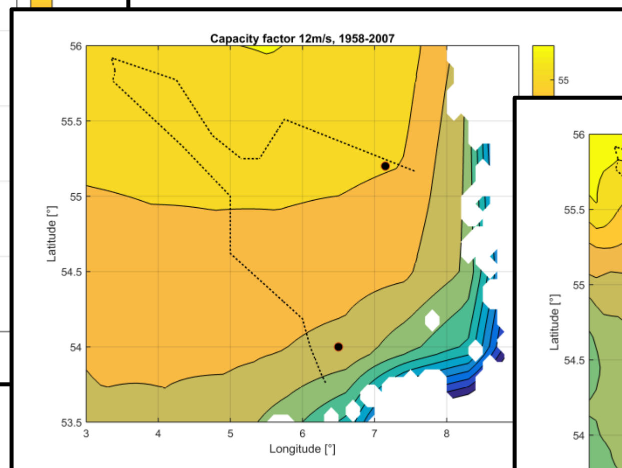
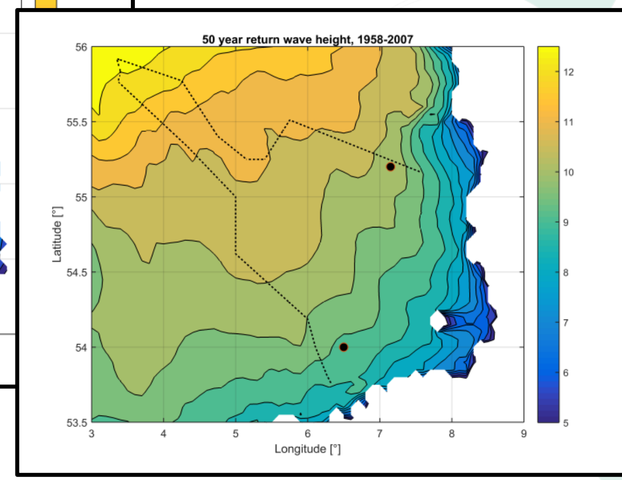
Maps of Parameters



Mean wind speed



Capacity factor



Extreme sea states

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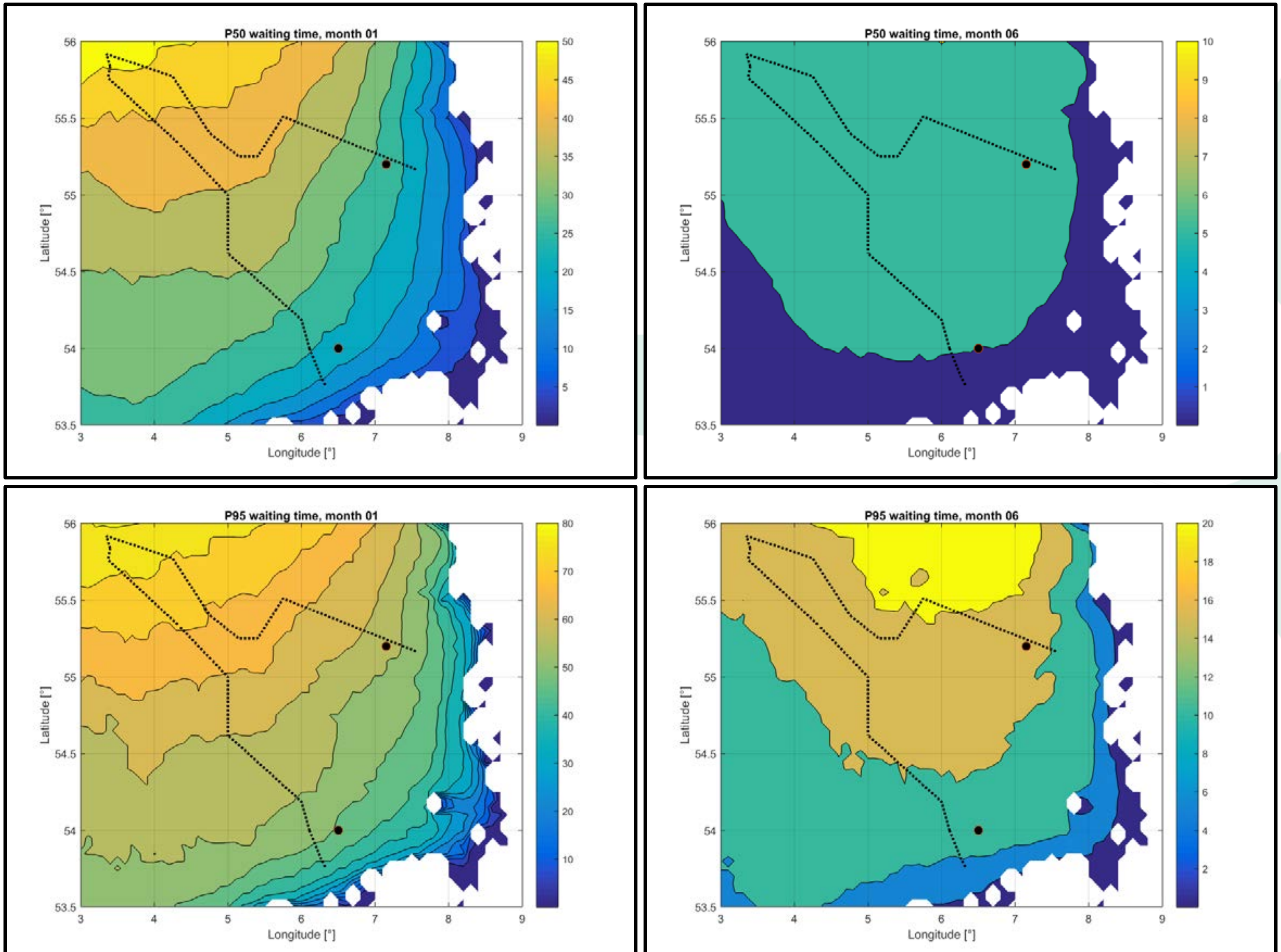
Maps of Project Downtimes



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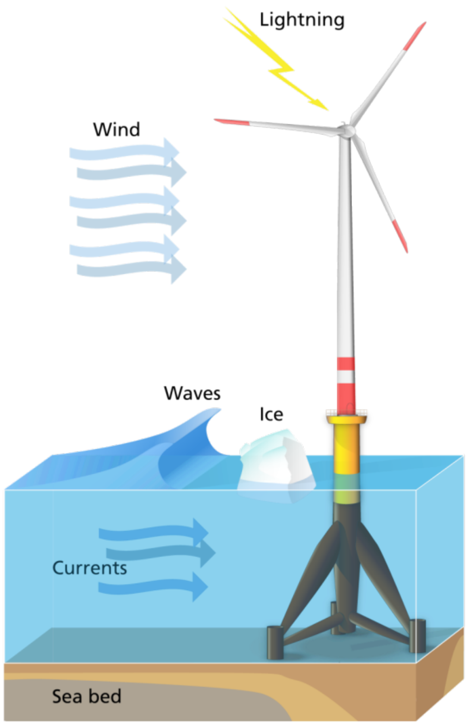

Figure: Florian Meier

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Further Fields of Application
Comparison of Installation Strategies

SZENARIO I	SCENARIO II	SZENARIO III
Classical Approach	Specified Installation Vessel	Floating Structure (Feeder Strateegy)

www.scaldis.com

- H_S = 1,5m; U = 10m/s
- Costs: 150.000 €/d
- Cost efficient, high weather risk

www.hochtief.de

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- Costs: 250.000 €/d
- Expensiv, lower weather risk

www.wordpress.com

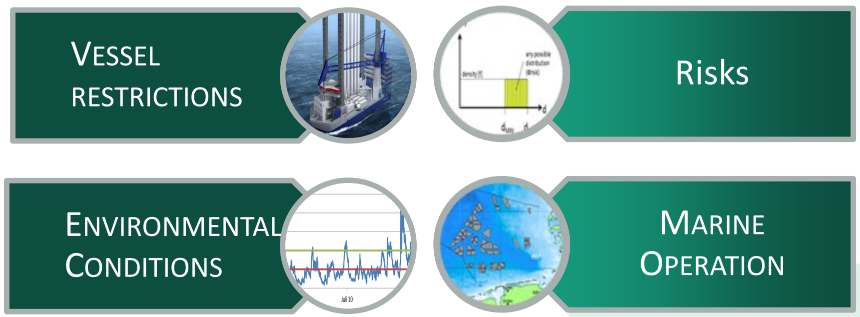
- H_S = 1,0m, U = 10m/s
- Costs: 100.000 €/d
- Cost efficient, high weather risk

LIMITS

Fields of Application

- Transport and Installation
  - Analysis and optimization of project schedules, costs and risks; overall project plan
  - Analysis and optimization of vessel and installation concepts; vessel designs
  - Analysis and optimization of contractual payments, penalties and weather risk distribution
  - Determination of remaining weather risks during installation
  - Proof of project progress, delays or working times, claim management
  - Support to determine insurance cover
- Operation and Maintenance
  - Analysis and optimization of planned and simple condition based maintenance
  - Analysis and optimization of large component replacements
  - Prediction of accessibility
  - Analysis, comparison and optimization of (seasonal) accessibility strategies
  - Analysis and optimization of weather risk distribution for vessel clubs
- Civil Engineering
  - All fields of application adapted for Civil Engineering topics

Summary



- COAST Approach:
  - Assess the weather risk
  - Combating the weather risk by scenario investigations
  - Case studies for different locations

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Acknowledgements

Fraunhofer IWES is funded by the:

Federal State of Bremen

- Senator für Umwelt, Bau, Verkehr und Europa
- Senator für Wirtschaft und Häfen
- Senatorin für Bildung und Wissenschaft
- Bremerhavener Gesellschaft für Investitions-Förderung und Stadtentwicklung GmbH

Federal State of Lower Saxony

Federal Republic of Germany

Federal Ministry for Economic Affairs and Energy (BMWi)
with support of the European Regional Development Fund (ERDF)

Bremerhaven Bremen

Lower Saxony

Supported by:

Federal Ministry for Economic Affairs and Energy

on the basis of a decision by the German Bundestag

EUROPEAN UNION
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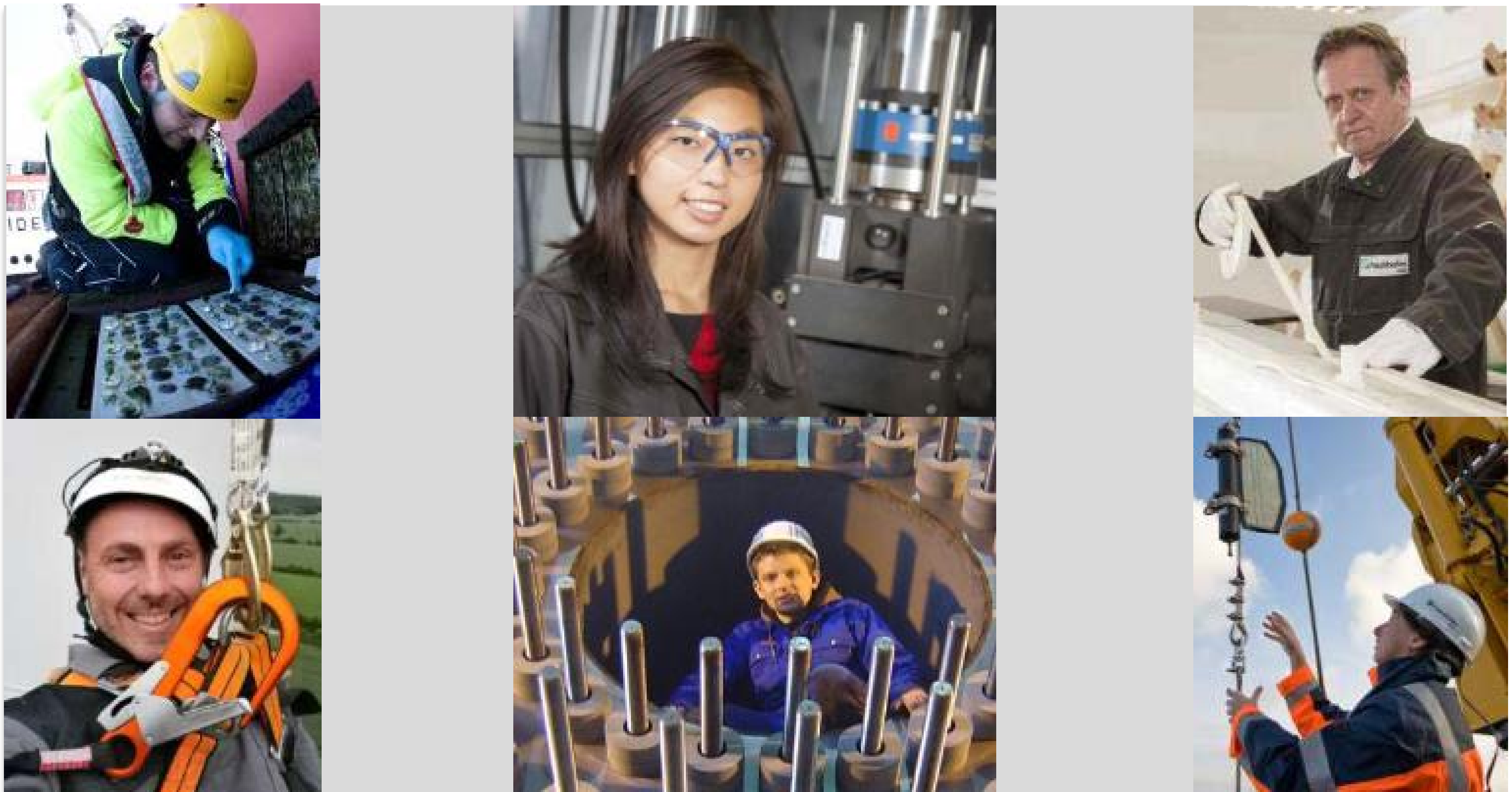
Fraunhofer IWES

Our employees are all

innovation accelerators efficiency boosters competence linkers



concept expanders knowledge intensifiers planing securers

THANK YOU FOR YOUR ATTENTION

Any questions?

marcel.wiggert@iwes.fraunhofer.de

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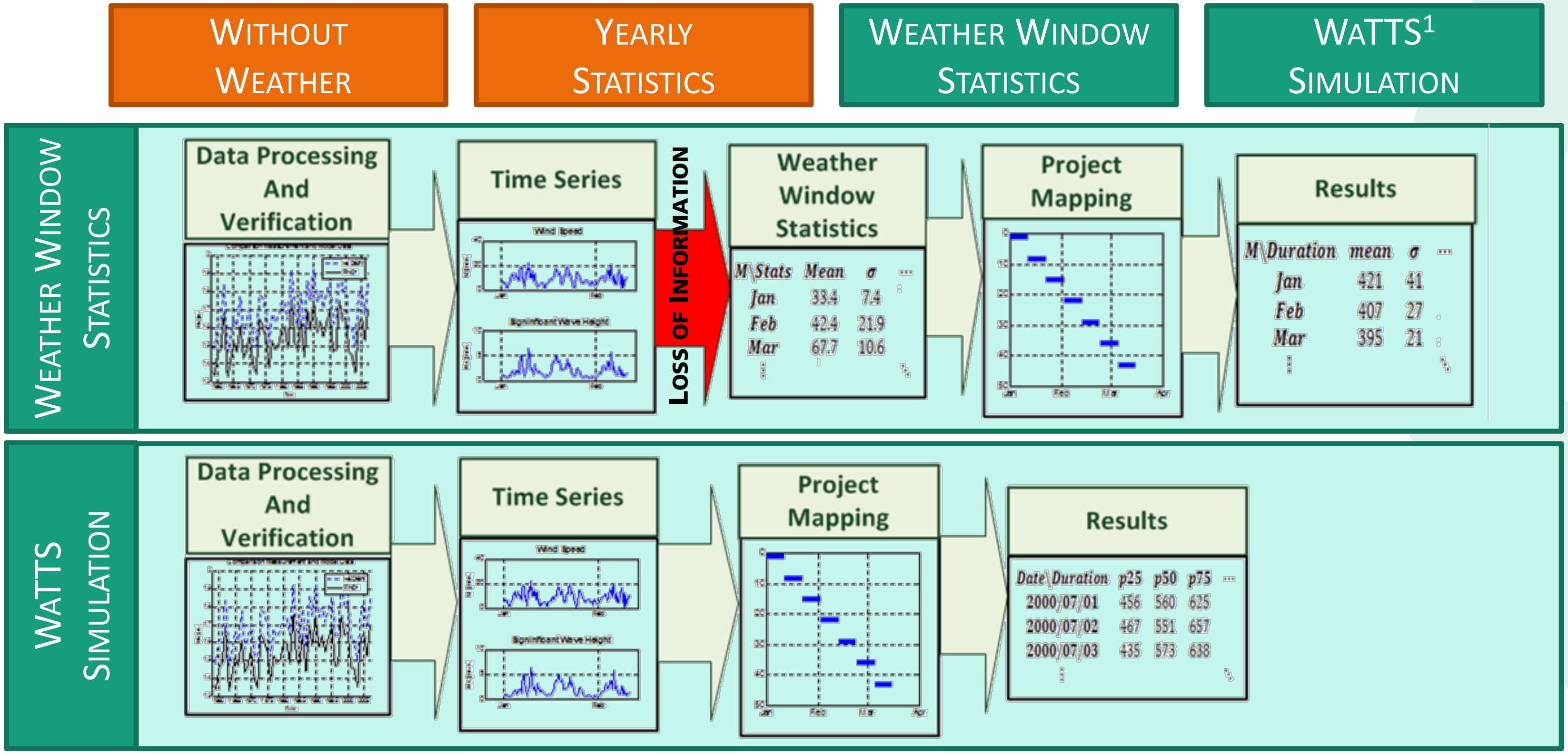
Background

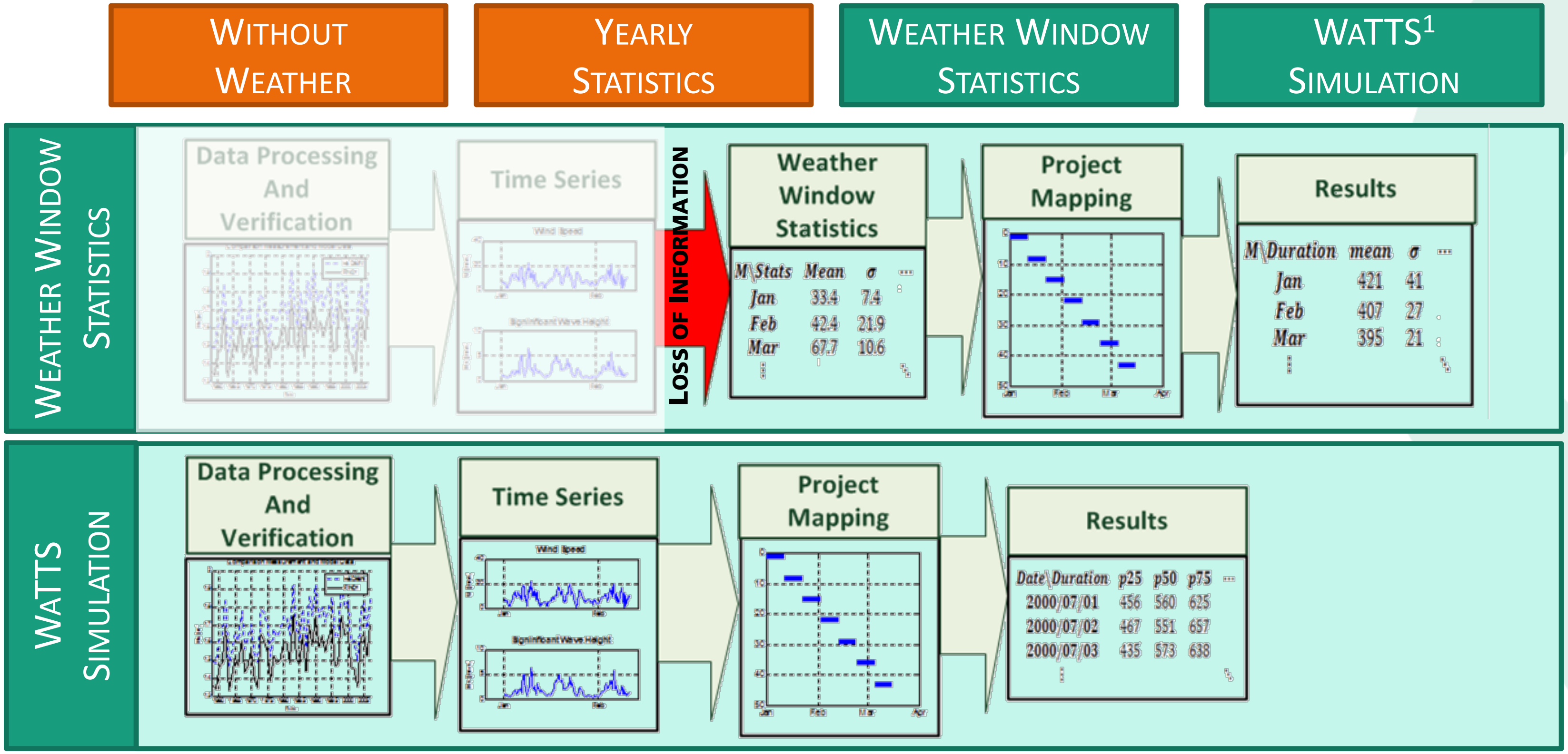
DETAILED INFORMATION

Methods to Forecast Weather Dependent Activity Durations



[1] WaTTS - Weather Time Series Scheduling

Methods to Forecast
Weather Dependent Activity Durations



[1] WaTTS - Weather Time Series Scheduling

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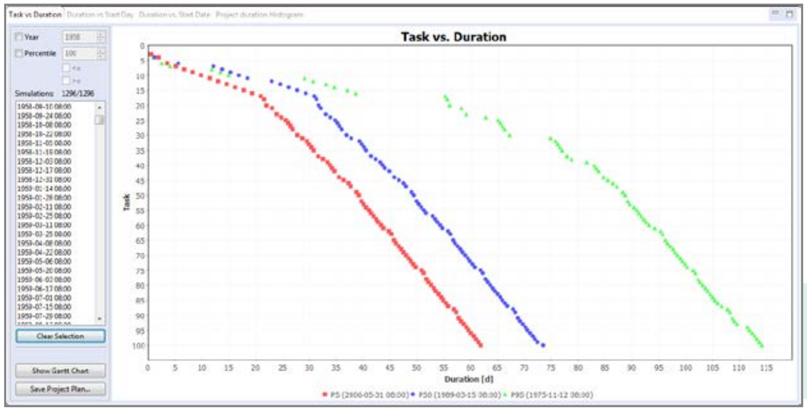
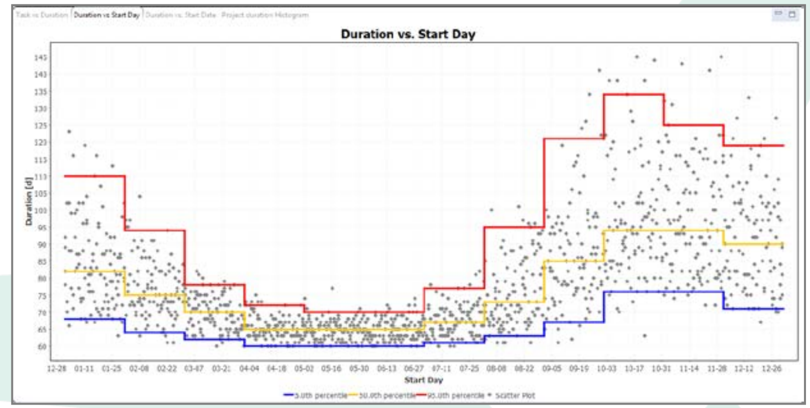
COAST – Results

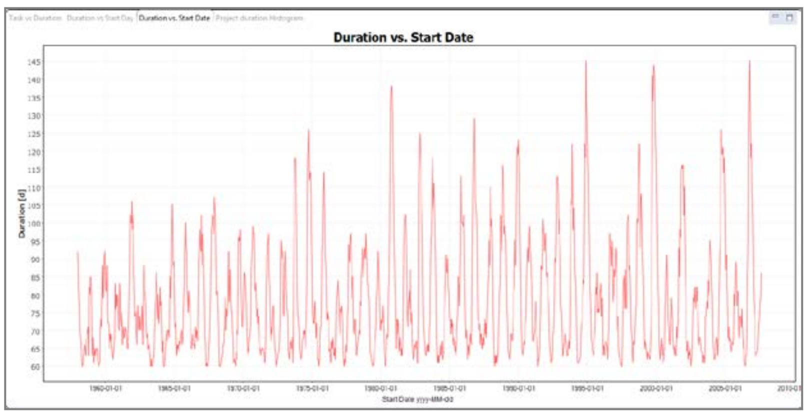
Simulated Project Plan



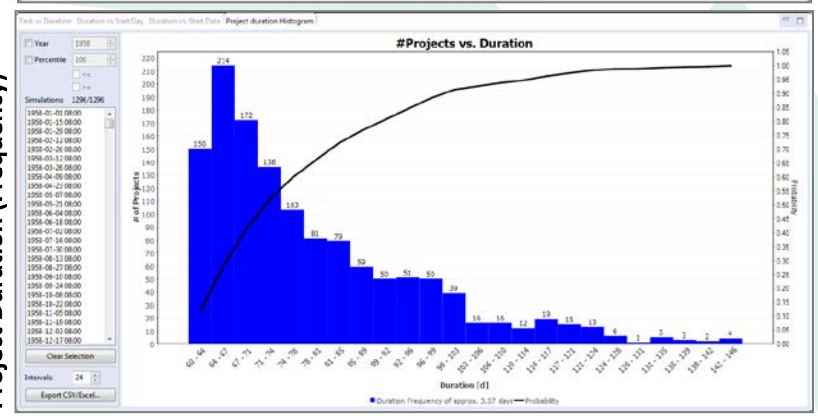
Generalized Year



Start Date vs. Project Duration



Project Duration (Frequency)



- All results can be exported as .csv for further MS Excel use

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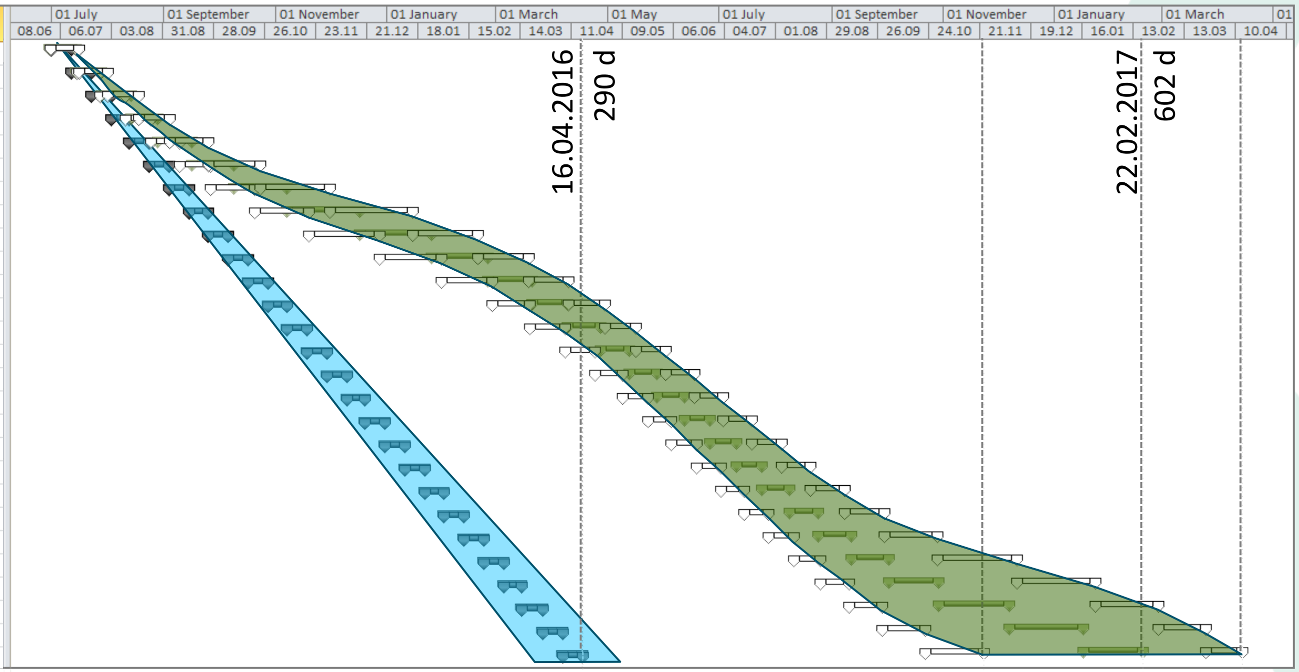
Schedule Risk Analysis Example

- Project plan: including weather influence and project risks

Name	Duration	Start	Finish
Jackets 1-3	10,45 dys	01.07.15	15.07.15
Jackets 4-6	9,85 dys	15.07.15	30.07.15
Jackets 7-9	10,45 dys	30.07.15	14.08.15
Jackets 10-12	9,8 dys	14.08.15	29.08.15
Jackets 13-15	9,8 dys	29.08.15	18.09.15
Jackets 16-18	10 dys	18.09.15	10.10.15
Jackets 19-21	9,35 dys	10.10.15	08.11.15
Jackets 22-24	9,1 dys	08.11.15	18.12.15
Jackets 25-27	9,35 dys	18.12.15	27.01.16
Jackets 28-30	9,1 dys	27.01.16	27.02.16
Jackets 31-33	9,4 dys	27.02.16	22.03.16
Jackets 34-36	9,65 dys	22.03.16	11.04.16
Jackets 37-39	9,9 dys	11.04.16	29.04.16
Jackets 40-42	9,75 dys	29.04.16	15.05.16
Jackets 43-45	10,3 dys	15.05.16	30.05.16
Jackets 46-48	9,85 dys	30.05.16	14.06.16
Jackets 49-51	10,4 dys	14.06.16	28.06.16
Jackets 52-54	9,9 dys	28.06.16	13.07.16
Jackets 55-57	10,4 dys	13.07.16	27.07.16
Jackets 58-60	9,95 dys	27.07.16	11.08.16
Jackets 61-63	10,3 dys	11.08.16	27.08.16
Jackets 64-66	9,7 dys	27.08.16	14.09.16
Jackets 67-69	9,75 dys	14.09.16	05.10.16
Jackets 70-72	9,35 dys	05.10.16	01.11.16
Jackets 73-75	9,25 dys	01.11.16	10.12.16
Jackets 76-78	9,2 dys	10.12.16	20.01.17
Jackets 79-81	9,35 dys	20.01.17	22.02.17



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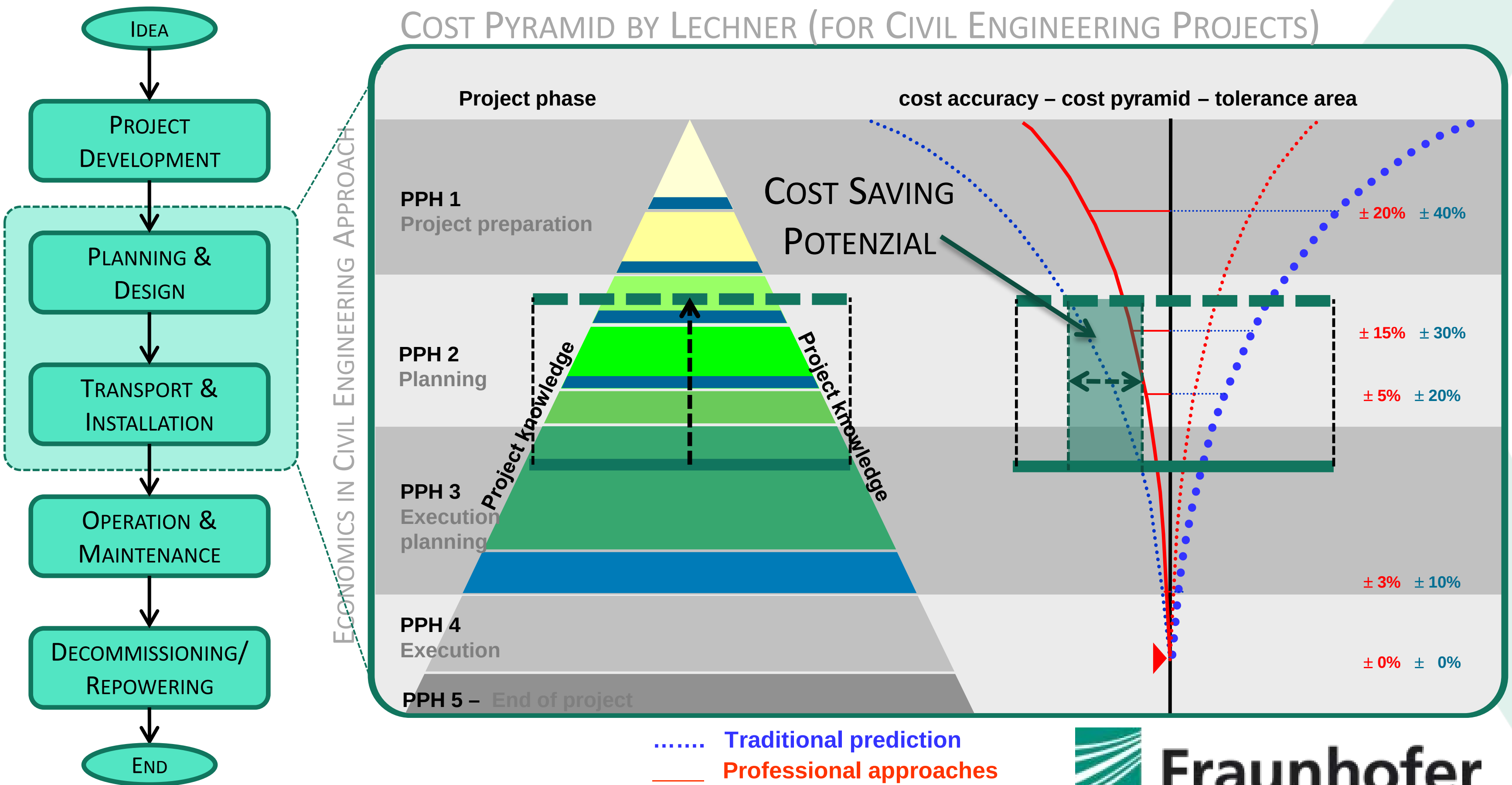
Cost Pyramid
Significance of Early Decisions



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