Welcome

WIND . ASSURING CONFIDENCE THROUGH COMPETENCE

Analysis, comparison and optimization of the logistical concept for wind turbine commissioning

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Fraunhofer IWES

Agenda & Goals

- Topic and challenges
- Introduction WaTSS concept
- Approach
- Case study: Commissioning
- Conclusions

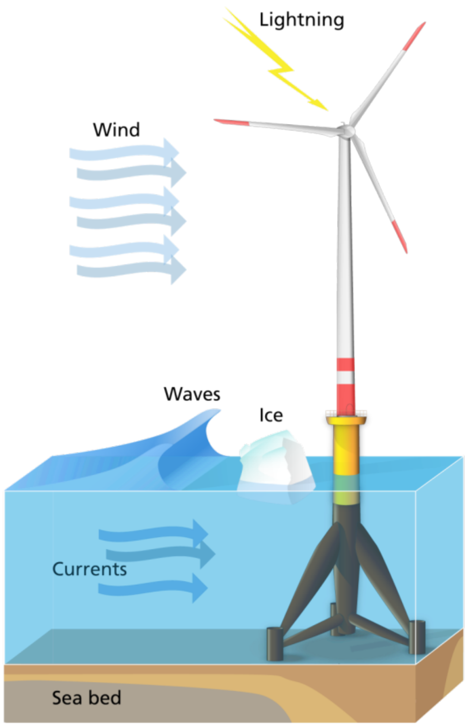

Figure: Florian Meier

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Topic

- Title:

Analysis, comparison and optimization
of the logistical concept for wind turbine commissioning

- Conditions:
  - Weather risk of the WTG installation
  - Optimization of the number of commissioning teams
  - Comparison of 3 different logistical concepts

- Decision criteria: lowest cost and risks

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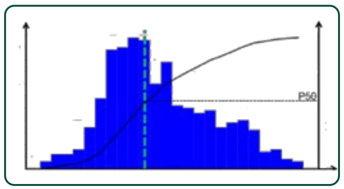
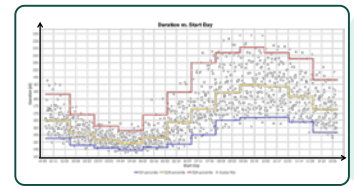
Challenge



WTG_i
Completion

Weather
Risks



WTG_i
Access for
commissioning

Installation

COAST[1]

- Comparison of logistical concepts
- **Commissioning team optimization**

Commissioning

COAST[1]

Resource
issue

[1] COAST – Comprehensive Offshore Analysis and Simulation Tool

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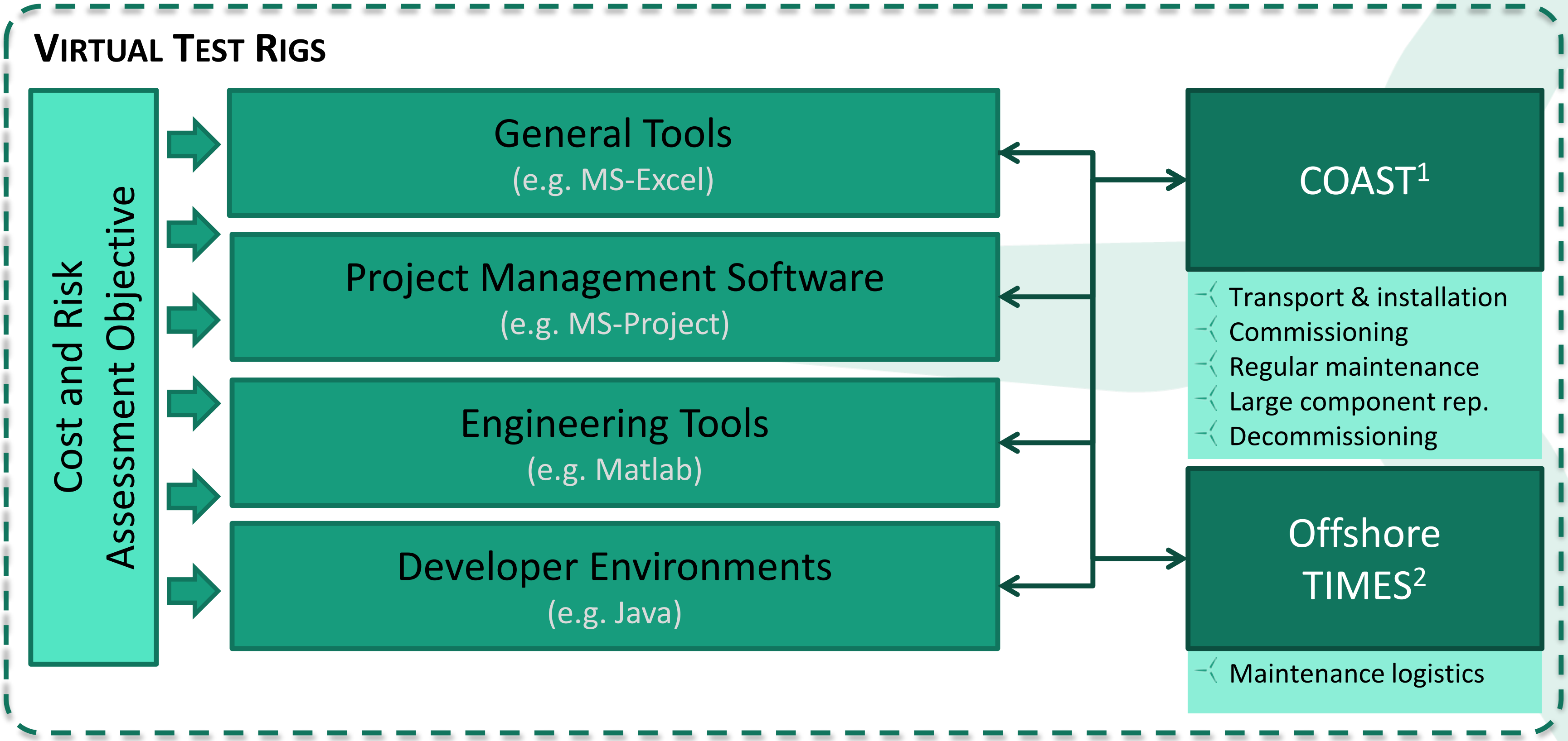
IWES Modeling Approaches



[1] COAST – Comprehensive Offshore Analysis and Simulation Tool
[2] Offshore TIMES – Offshore Transport, Inspection an Maintenance Software

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 cabling processes and sequences
- Project overall project time schedule

Project Schedules

Installation Strategy

- Location wind farm/ ports
- Vessel and equipment concept
- Guideline requirements
- Contractual agreements

Boundary Conditions

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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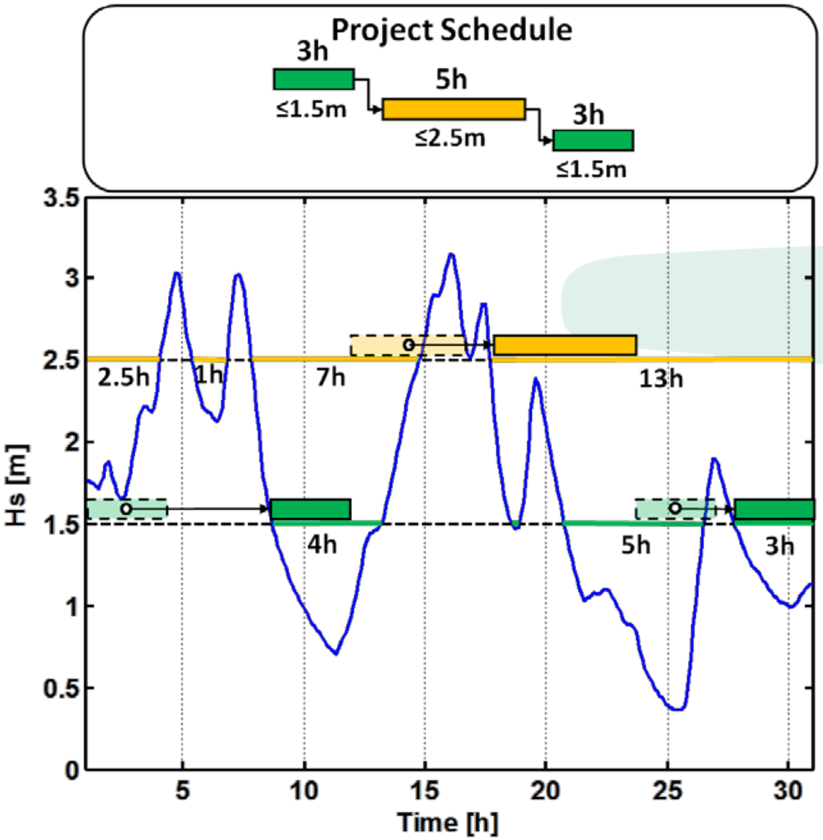
WaTTS – Method
Weather Time Series Scheduling



- Consideration of:
  - Task sequence
  - Contingencies in guidelines
  - Different weather restrictions
- Calculation of project durations and their probabilities

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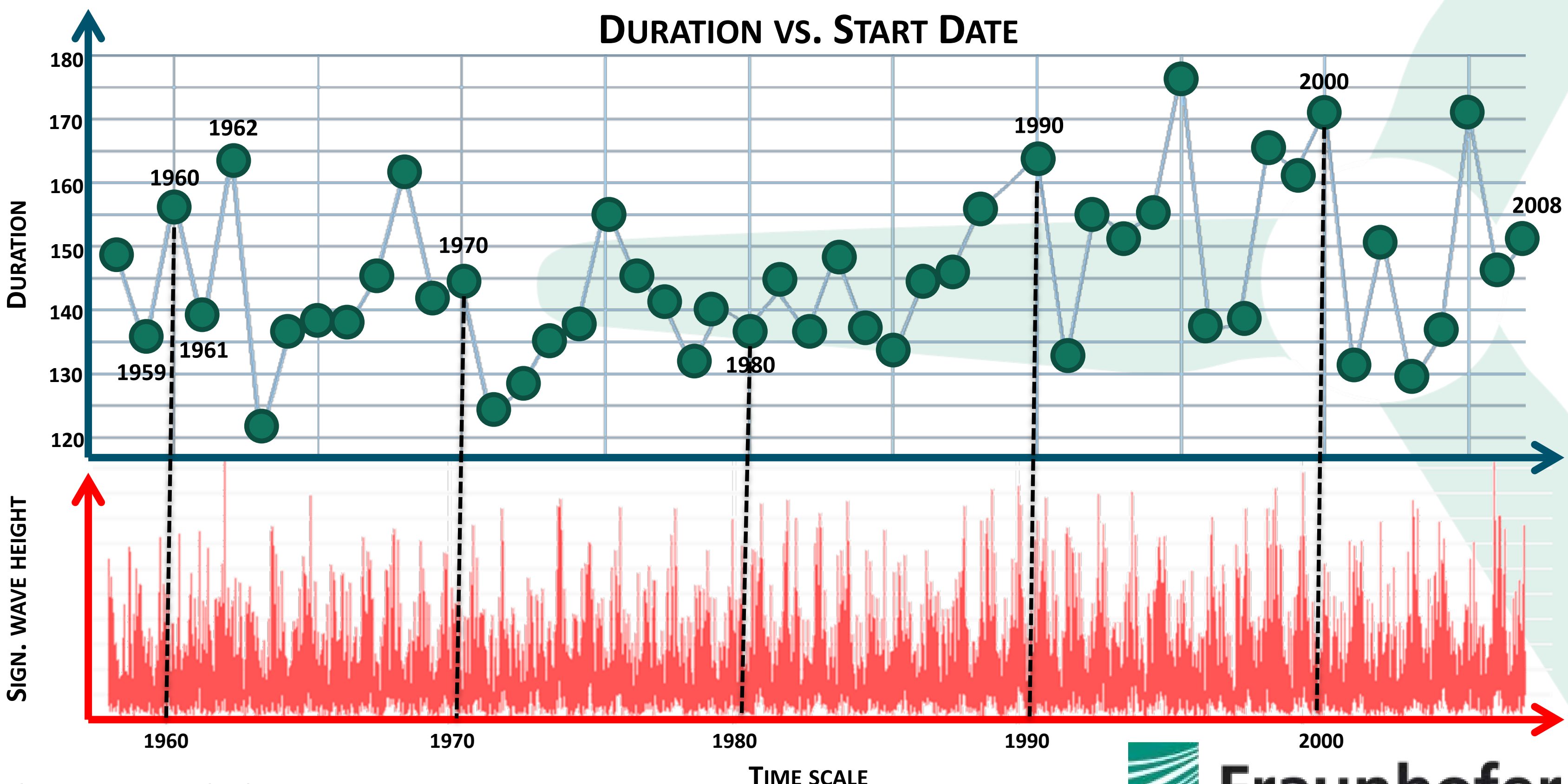
Virtual Project Test Center
Yearly Simulation



START DATE: E.G. 01.01.

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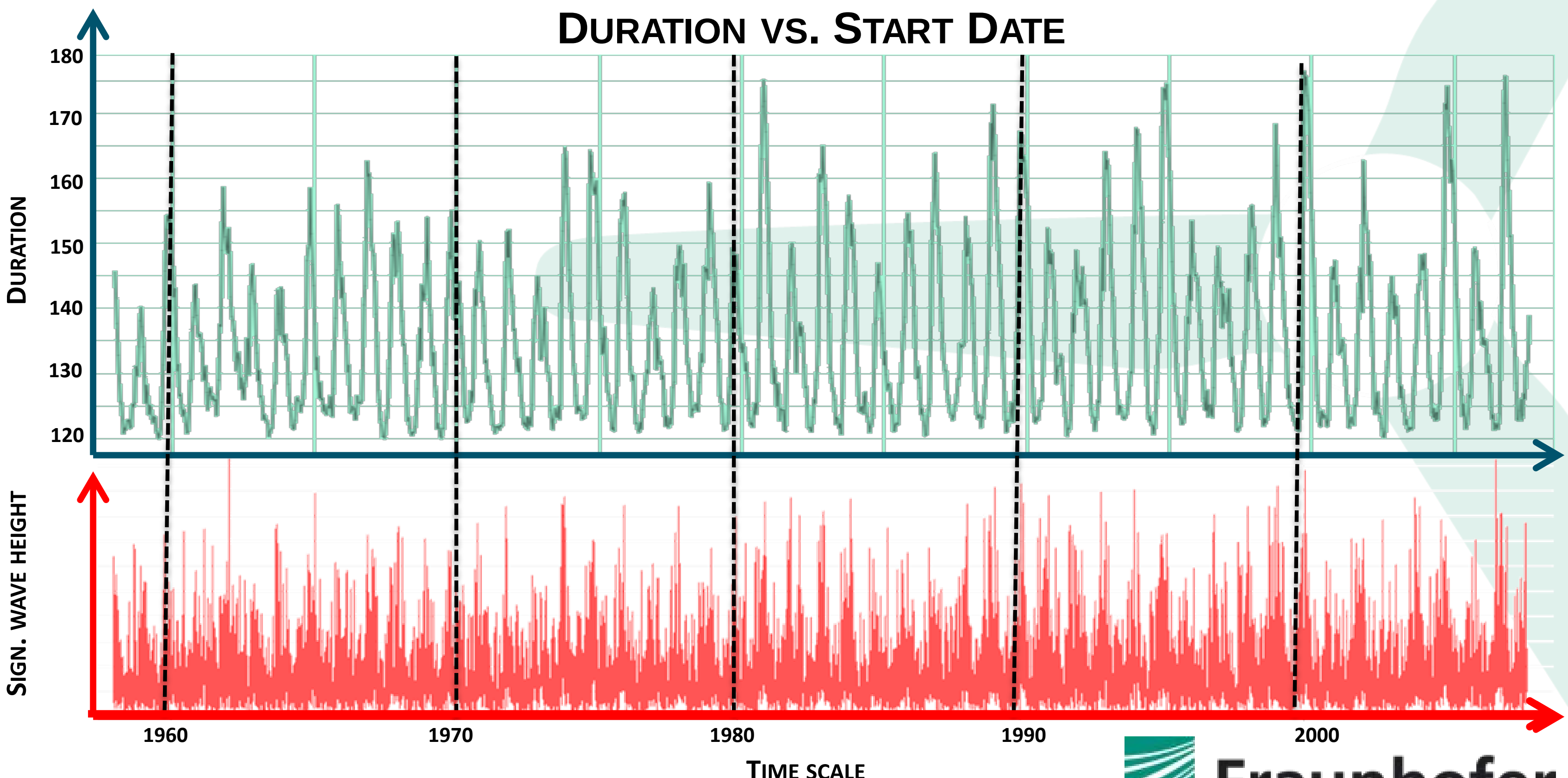
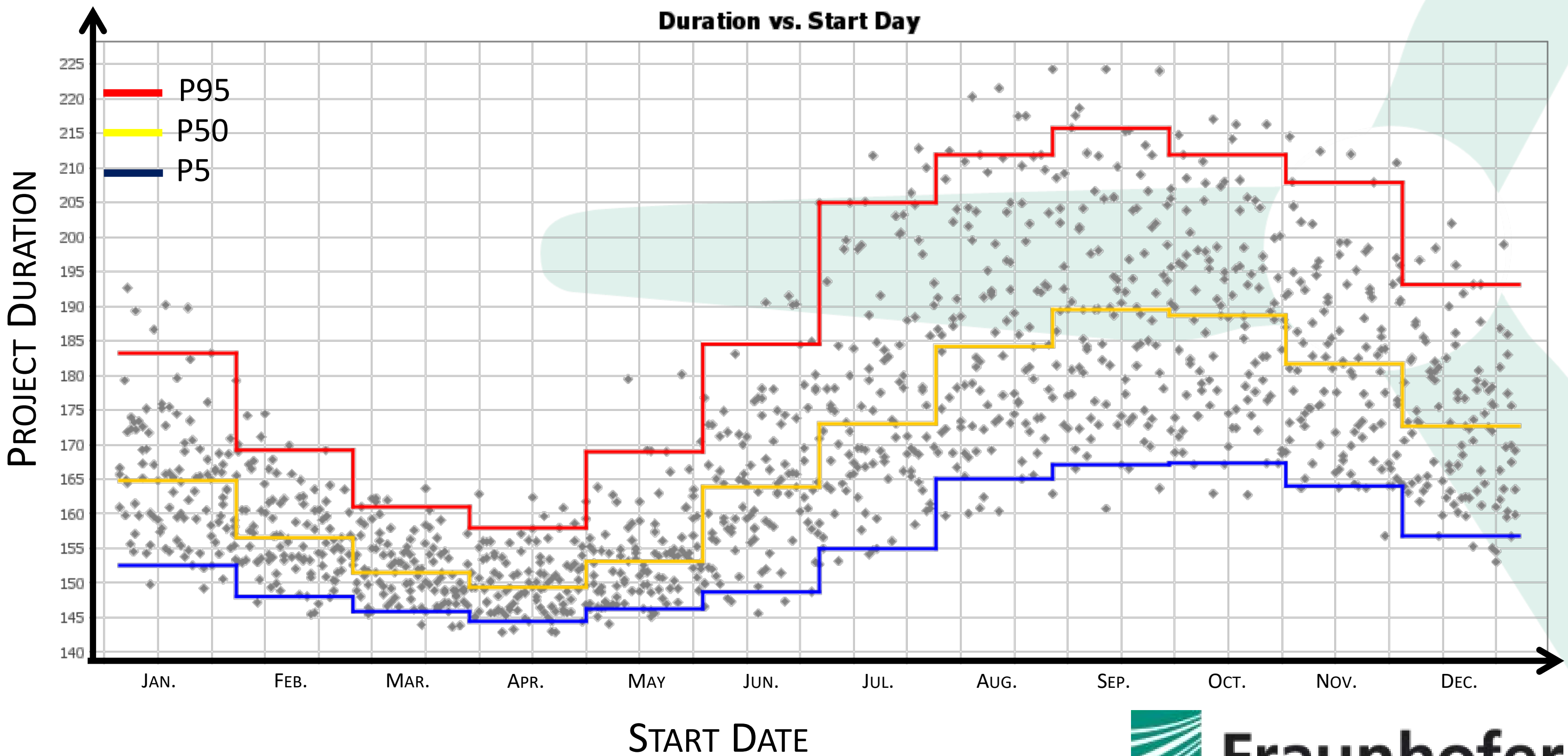
Virtual Project Test Center
Continuous Simulation



Duration vs. Start Day



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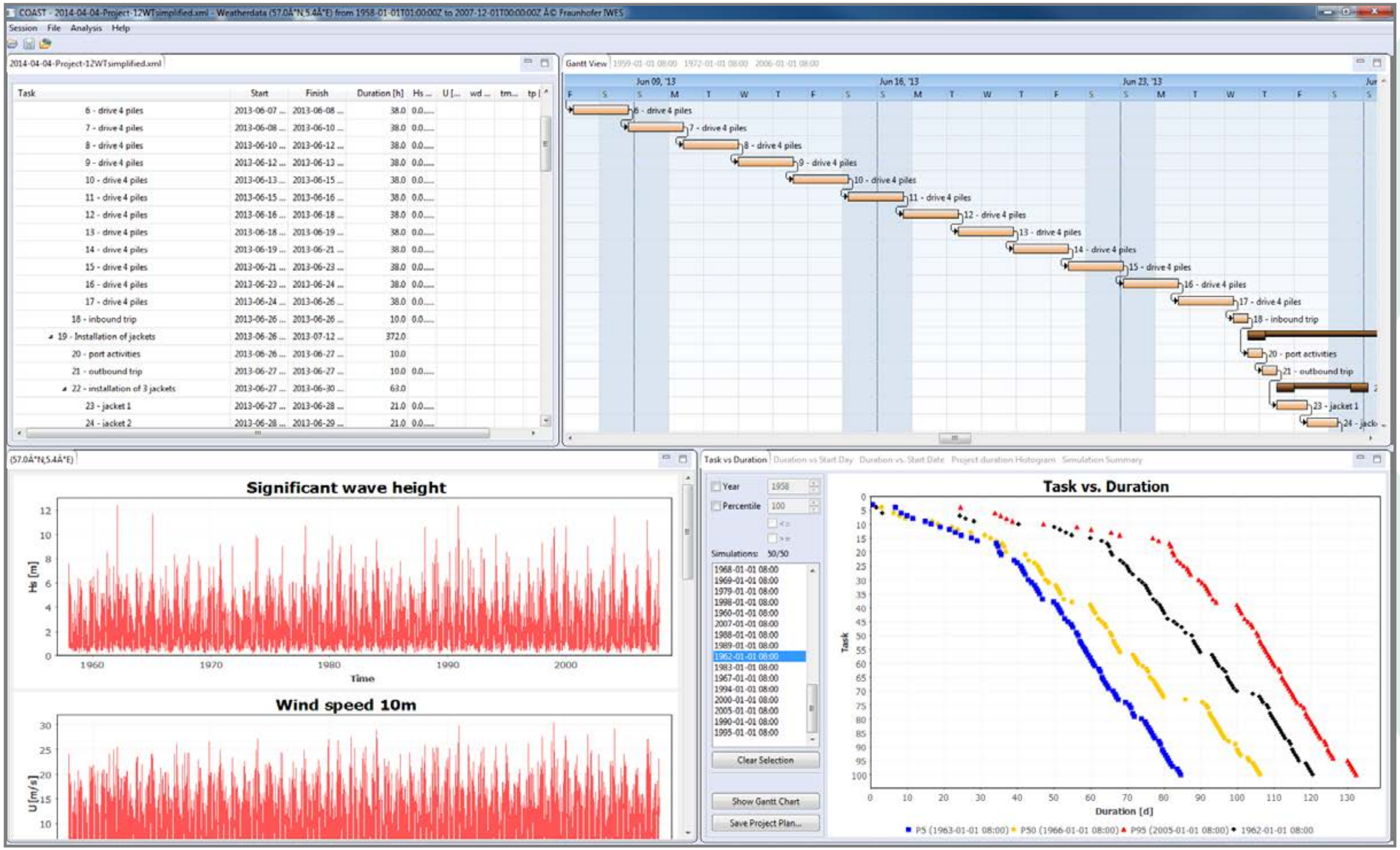
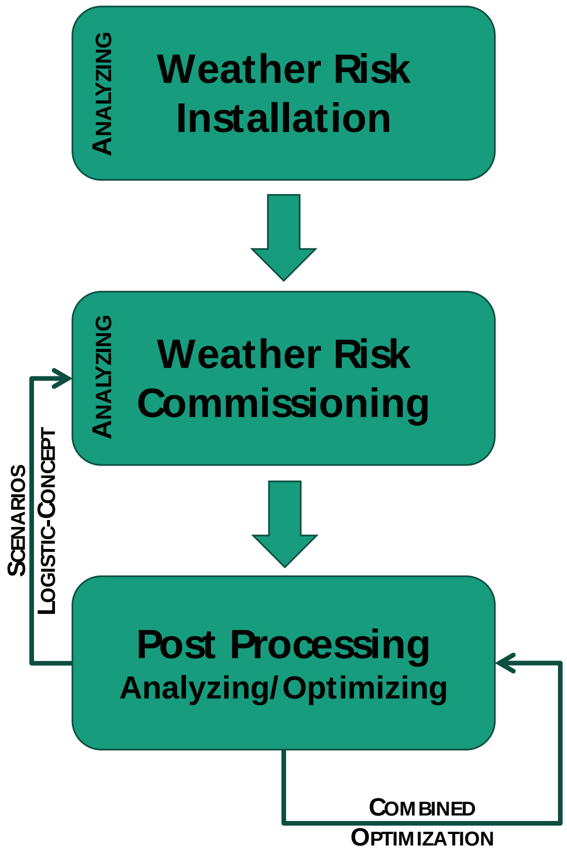
COAST – Software



Simulation Concept



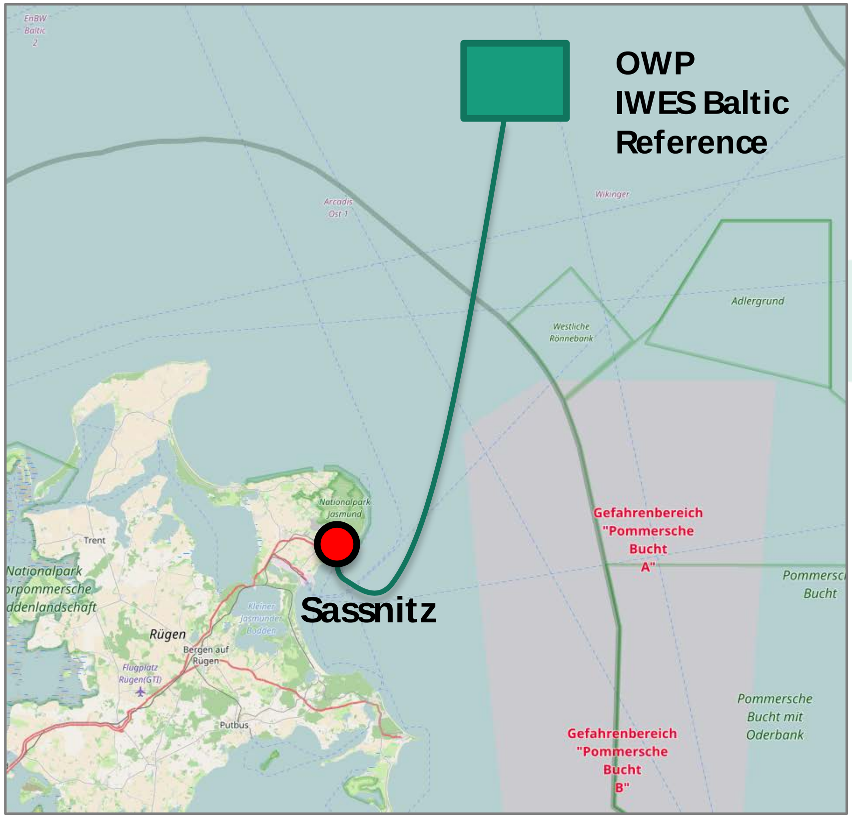
1. Installation dates of the wind turbines per analyzed year
   Goal: Definition commissioning start dates
2. Success of the commissioning work for every day
   Goal: Definition of the turbine accessibility
3. Post Processing: e.g., MS Excel or MATLAB
   Goal: Analyzing the scenarios

   ① Calculation of the commissioning duration per turbine and year under consideration of weather and resource constraints

   ② Calculation of the required vessel days and costs

   ③ Evaluation and presentation of the results

Case Study: IWES Baltic
Introduction



IWES OWP Baltic

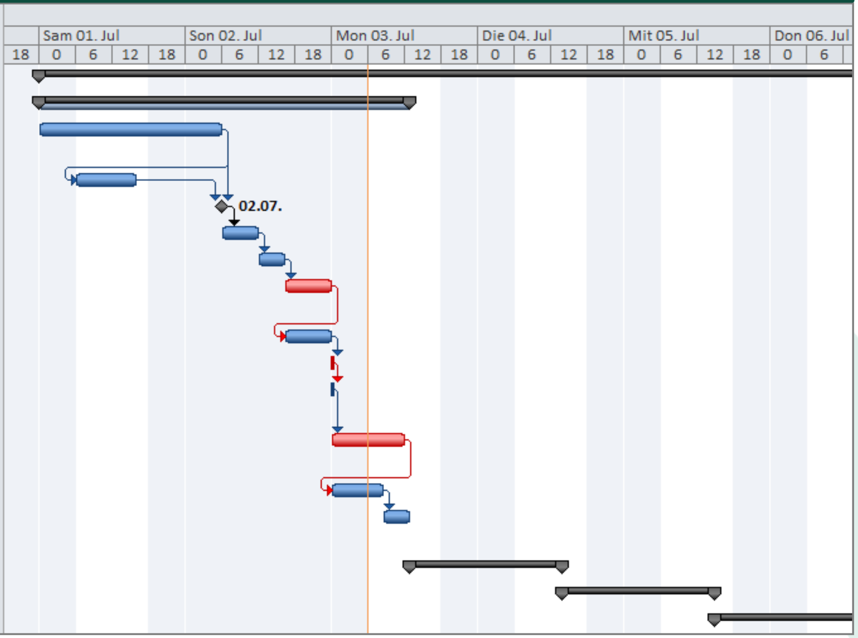
Boundary conditions	Assumption
Number of turbines	60
Port distance	40km
Start date	2020-07-01
Commissioning (1 Team)	160h/turbine (net)
Team costs	3,000 Euro/day
Opportunity costs	3,000 Euro/day per turbine
Weather data	coastDat v1 (1958–2002) [4]
Duration of installation incl. weather risks (P50)	100 days (COAST)

- Weather parameters:
  - Significant Wave Height (h_S)
  - Wind Speed (U)

WTG Installation Strategy

WTG Installation Strategy only

	Vor	Vorgangsname	Dauer	Anfang	Fertig stellen
1		**WTG Installation**	**2100 Std.**	**Sa 01.07.17 00:00**	**Di 26.09.17 12:00**
2		**WTG 1**	**61 Std.**	**Sa 01.07.17 00:00**	**Mo 03.07.17 13:00**
3		Loading in Harbour	32 Std.	Sa 01.07.17 00:00	So 02.07.17 08:00
4		Crain Works	8 Std.	Sa 01.07.17 08:00	Sa 01.07.17 16:00
5		Jack down	0 Std.	So 02.07.17 08:00	So 02.07.17 08:00
6		Transit to Site	4 Std.	So 02.07.17 08:00	So 02.07.17 12:00
7		Jack Up	4,5 Std.	So 02.07.17 12:00	So 02.07.17 16:30
8		WW Tower Installation	7,5 Std.	So 02.07.17 16:30	Mo 03.07.17 00:00
9		Tower Installation	4 Std.	So 02.07.17 16:30	So 02.07.17 20:30
10		WW Nacelle	7,5 Std.	So 02.07.17 20:30	Mo 03.07.17 04:00
11		Nacelle Installation	4 Std.	So 02.07.17 20:30	Mo 03.07.17 00:30
12		WW Blade Installation	11,5 Std.	Mo 03.07.17 00:30	Mo 03.07.17 12:00
13		Blades 1-3	8 Std.	Mo 03.07.17 00:3	Mo 03.07.17 08:30
14		Jack Down+transit to next site	4,5 Std.	Mo 03.07.17 08:30	Mo 03.07.17 13:00
15		**WTG 2**	**25 Std.**	**Mo 03.07.17 13:0**	**Di 04.07.17 14:00**
24		**WTG 3**	**25 Std.**	**Di 04.07.17 14:00**	**Mi 05.07.17 15:00**
33		**WTG 4**	**29 Std.**	**Mi 05.07.17 15:0**	**Do 06.07.17 20:00**



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Scenario Analysis

Scenario CTV	Scenario HV	Scenario SOV
Crew Transfer Vessel	Hotel Vessel	Service Operation Vessel

www.pomaritime.com

https://c-bed.nl

www.siemens.com/windpower

Assumptions

CTV	HV	SOV
H_S = 1.5m;	H_S = 1.5m	H_S = 2.5m
3 Teams on board; 12h/7 days	20 Teams; 24h/7 days	20 Teams; 24h/7 days
Costs: 4,000 €/d	Costs: 20,000 €/d	Costs: 24,000 €/d
8h/day on turbine	10h/day on turbine	10h/day on turbine

Scenario Analysis

Scenario CTV

Crew Transfer Vessel

Vorgangsname	Dauer
12/7 CTV Base Case	12 Std.
1. WTG - Fahrt 1	12 Std.
Transfer to site	2 Std.
Comm Works	8 Std.
Transfer back to harbour	2 Std.

Assumptions

- H_S = 1.5m;
- 3 Teams on board; 12h/7 days
- Costs: 4,000 €/d
- 8h/day on turbine

Scenario HV

Hotel Vessel

Vorgangsname	Dauer
Accommodation Vessel 24/7	24 Std.
1. WTG - Fahrt 1	24 Std.
Transfer to site	1 Std.
Comm Works	10 Std.
Transfer back to Vessel	1 Std.
Transfer to site	1 Std.
Comm Works	10 Std.
Transfer back to Vessel	1 Std.

- H_S = 1.5m
- 20 Teams; 24h/7 days
- Costs: 20,000 €/d
- 10h/day on turbine

Scenario SOV

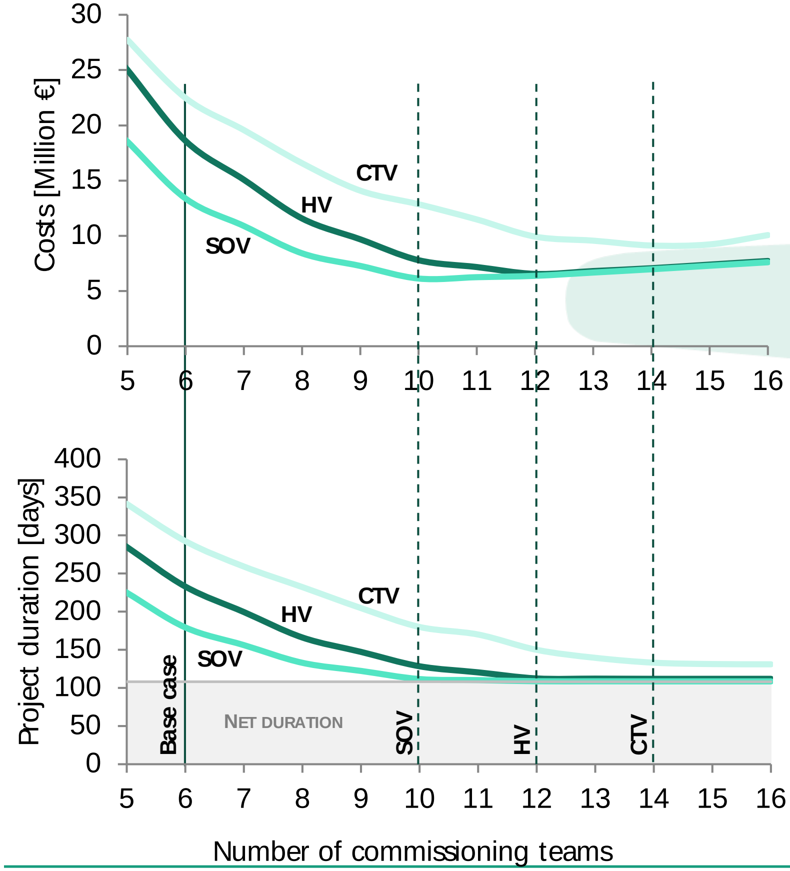
Service Operation Vessel

Vorgangsname	Dauer
DP2 Vessel	24 Std.
Fahrt 1	24 Std.
Transfer to site	1 Std.
Comm Works	10 Std.
Transfer back to Ve	1 Std.
Transfer to site	1 Std.
Comm Works	10 Std.
Transfer back to Ve	1 Std.

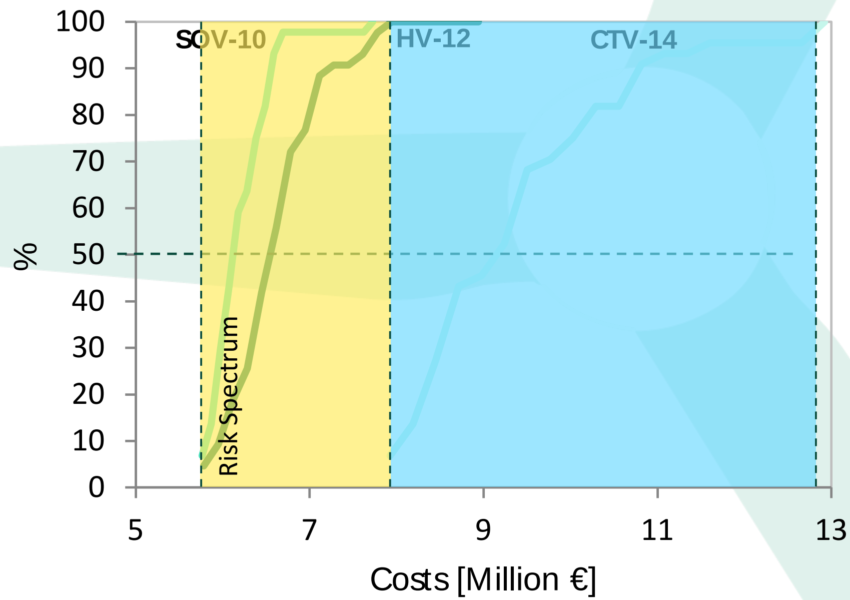
- H_S = 2.5m, U = 10 m/s
- 20 Teams; 24h/7 days
- Costs: 24,000 €/d
- 10h/day on turbine

Case Study: IWES Baltic – Results

Costs (P50)



Risk Profile



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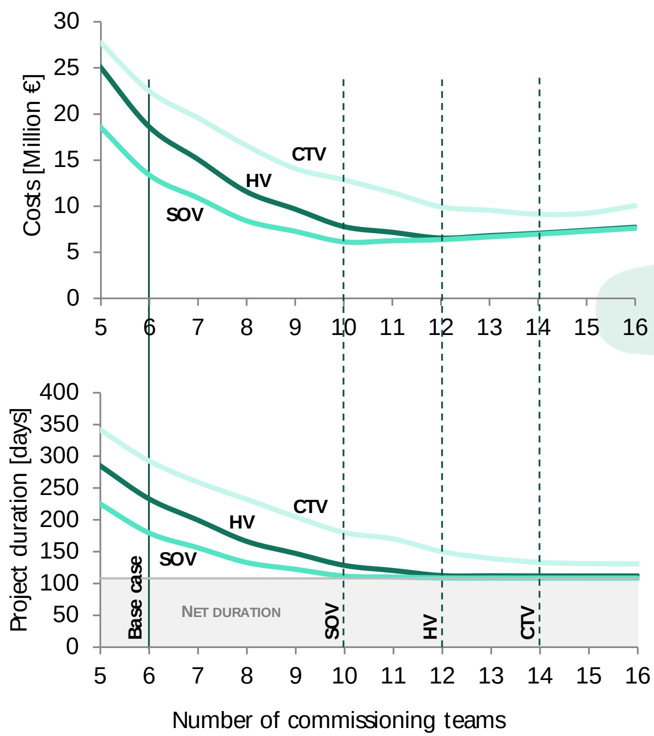
Conclusion



- Post processing extends capabilities of the WaTSS method
- Approach to consider the availability of transport (resources) for the commissioning teams
- Important to consider risks and cost simultaneously
- Case Study: “IWES Baltic”

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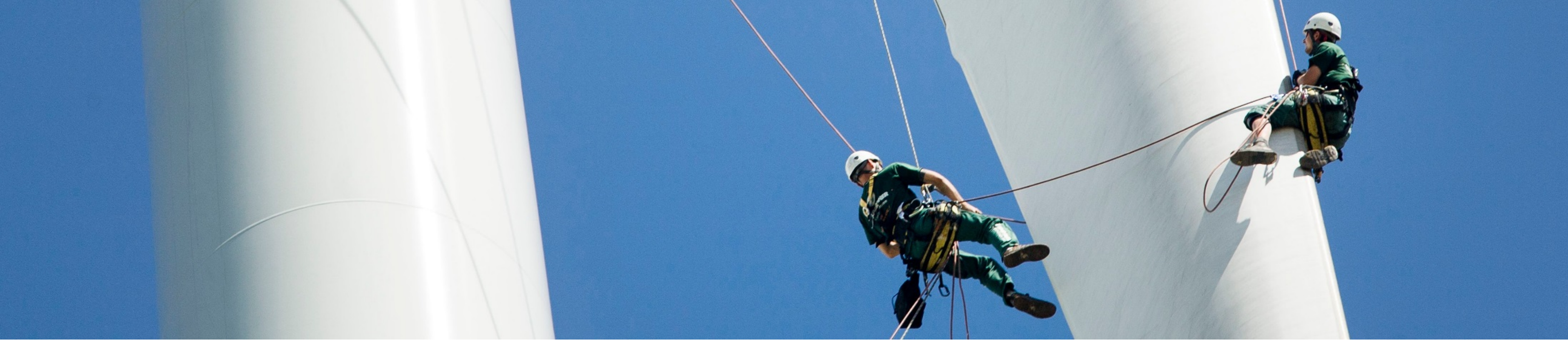

References

Adwen
AN AREVA GAMESA COMPANY

BASF
The Chemical Company

e·on

ENERCON
ENERGIE FÜR DIE WELT

Gamesa

GE Energy

NORDEX
We've got the power.

TenneT

SENVION
wind energy solutions

vallourec

VATTENFALL

weg

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Thank You For Your Attention

Any questions?

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Detailed Information

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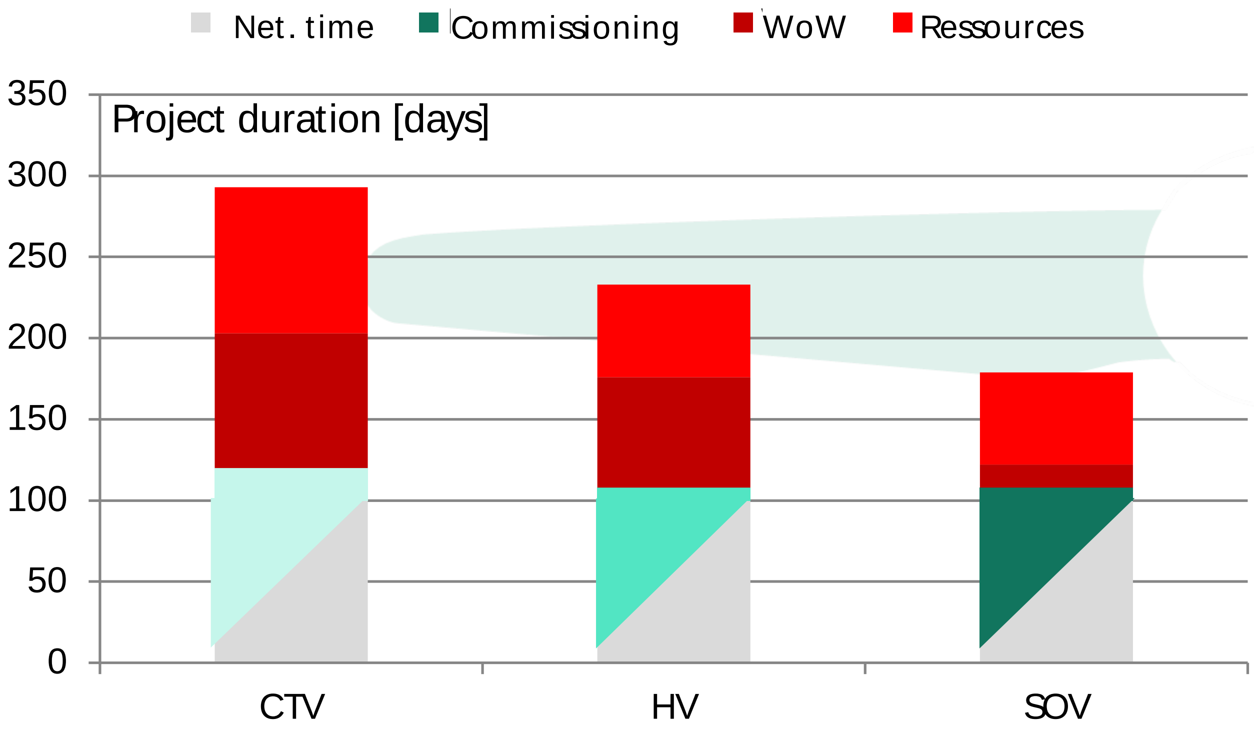
Detailed Analysis



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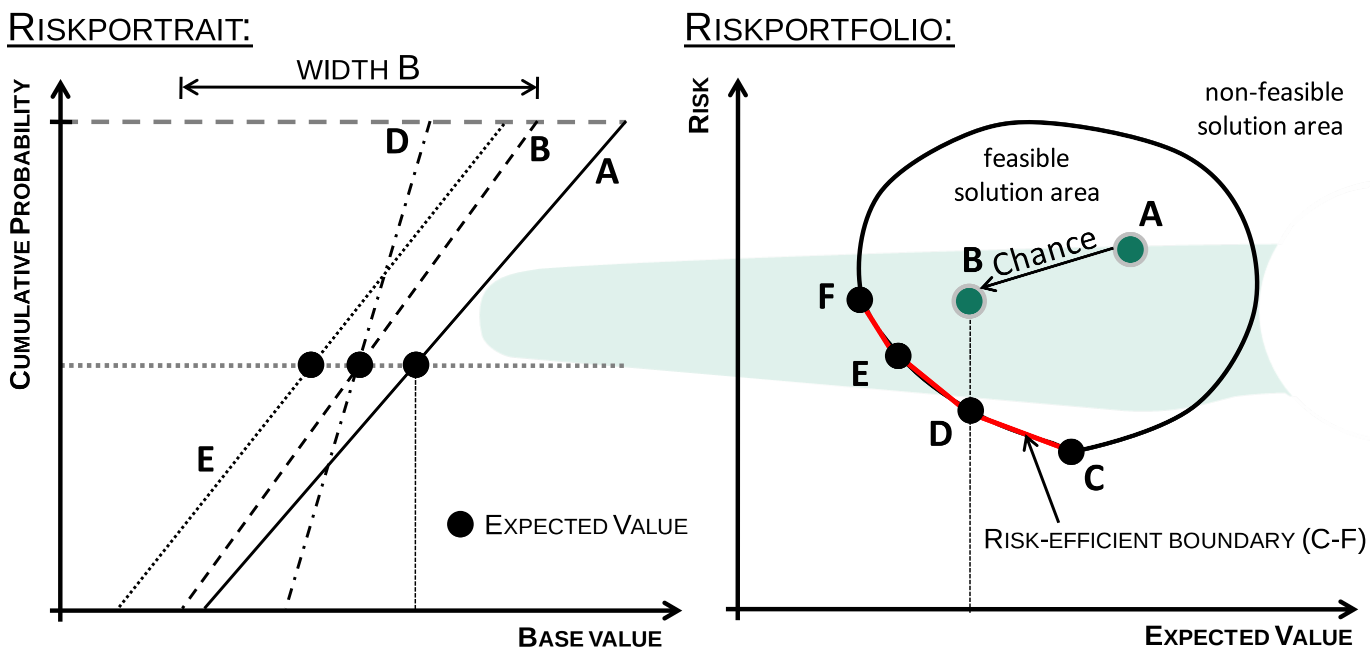
Risk Efficiency



- Risk efficiency concept by CHAPMAN/WARD 2003, based on MARKOWITZ portfolio theory
- Rule: *„that the investor does (or should) consider expected return a desirable thing <u>and</u> variance of return an undesirable thing“* (MARKOWITZ 1952, S.77)

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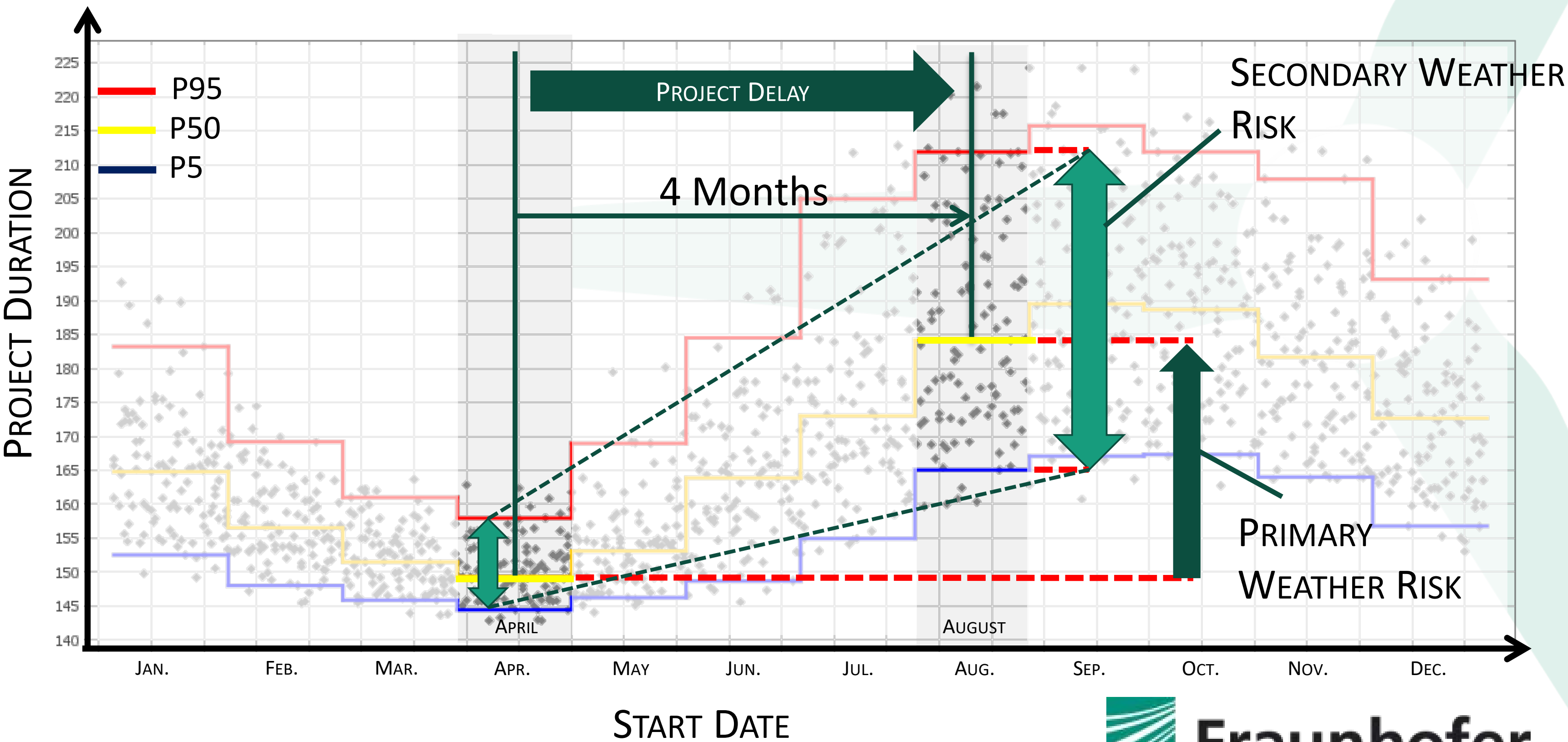
Primary and Secondary Weather Risks
Duration vs. Start Day



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Weather Impact – Example Accessibility (July – December)

h_S = 1.5m; Weather Window d= 10h; Data Model: HZG CoastDat v1 (1958–2007)