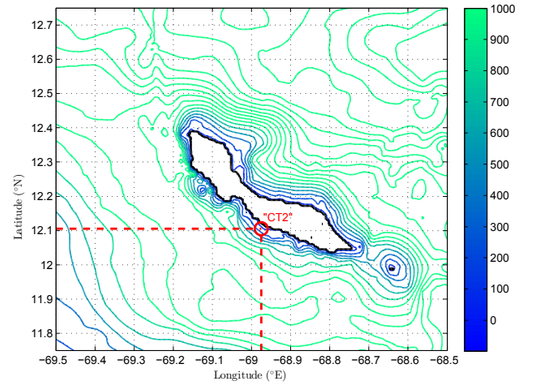
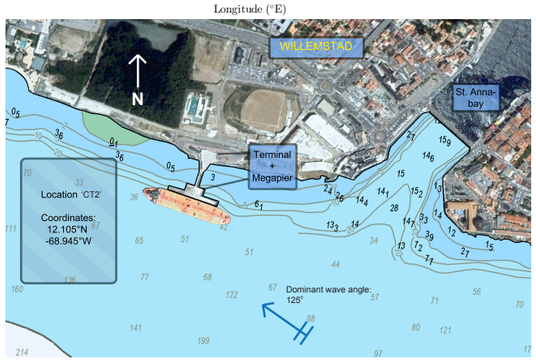
Chapter 2: Analysis

Project Location: Port Facilities & Current Situation





Deep Sea Wave Climate

BMT ARGOSS: Wind waves & Swell waves at Deep Sea

Wave Scatter Diagrams from Dataset with Wind Sea Waves:

Significant Wave Height vs. Wave Direction

Hs - S Significant Wave Height [m]	Wave Direction [deg] 0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	360	#	%
0 - 0.3	9	32	50	97	111	180	254	421	486	314	169	67	43	15	9	11	22	2434	4.0
0.3 - 0.6	5	19	15	43	103	205	504	1064	1697	1114	427	131	37	20	9	4	8	5489	9.1
0.6 - 0.9	2	2	7	21	43	240	732	2166	4265	2247	532	115	32	16	2	-	1	10449	17.3
0.9 - 1.2	-	-	1	14	44	225	827	2963	6744	2749	232	41	3	-	-	-	-	13854	22.9
1.2 - 1.5	-	-	7	18	26	139	682	2570	6641	2234	116	4	1	-	-	-	-	12447	20.5
1.5 - 1.8	-	-	-	-	20	74	446	1834	4690	1482	21	-	-	-	-	-	-	8572	14.2
1.8 - 2.1	-	-	-	-	5	40	179	1035	2671	823	11	-	-	-	-	-	-	4765	7.9
2.1 - 2.4	-	1	-	1	4	14	70	436	1108	296	2	-	-	-	-	-	-	1932	3.2
2.4 - 2.7	-	-	-	-	-	1	31	103	292	65	1	-	-	-	-	-	-	493	0.8
2.7 - 3.0	-	-	-	-	1	3	9	37	56	6	-	-	-	-	-	-	-	112	0.2
3.0 - 3.3	-	-	-	-	-	-	2	15	2	3	-	-	-	-	-	-	-	22	0.0
3.3 - 3.6	-	-	-	1	-	-	1	1	-	-	-	-	-	-	-	-	-	3	0.0
#	16	54	80	195	357	1121	3737	12645	28652	11333	1511	358	116	51	20	15		60572	
%	0	0	0	0.3	0.6	1.9	6.2	20.9	47.3	18.7	2.5	0.6	0.2	0.1	0	0			100

Significant Wave Height vs. Peak Wave Period

Hs - S Significant Wave Height [m]	Tp - Wave Peak Period [s] 3.2	3.6	3.9	4.3	4.7	5.2	5.7	6.3	6.9	7.6	8.4	9.2	10.2	#	%
0 - 0.3	326	195	96	39	7	5	-	-	-	-	-	-	-	668	1.1
0.3 - 0.6	1060	1480	1220	756	359	128	37	7	7	-	-	-	-	5054	8.7
0.6 - 0.9	38	377	1412	3302	3042	1586	516	110	49	18	4	-	-	10454	17.9
0.9 - 1.2	-	-	64	785	3513	5372	3106	774	165	62	12	1	-	13854	23.7
1.2 - 1.5	-	-	-	6	414	3421	5177	2694	574	122	34	5	-	12447	21.3
1.5 - 1.8	-	-	-	-	-	2	320	3110	3726	1210	172	26	6	8572	14.7
1.8 - 2.1	-	-	-	-	-	-	1	316	2486	1589	332	34	7	4765	8.2
2.1 - 2.4	-	-	-	-	-	-	-	-	349	1179	366	34	3	1932	3.3
2.4 - 2.7	-	-	-	-	-	-	-	-	7	240	208	36	2	493	0.8
2.7 - 3.0	-	-	-	-	-	-	-	-	-	10	75	26	1	112	0.2
3 - 3.3	-	-	-	-	-	-	-	-	-	-	6	16	-		
3.3 - 3.6	-	-	-	-	-	-	-	-	-	-	-	2	-		
3.6 - 3.9	-	-	-	-	-	-	-	-	-	-	-	1	-		
#	1424	2052	2792	4888	7337	10833	12262	10153	5023	1355	206	25	1	58351	
%	2.4	3.5	4.8	8.4	12.6	18.6	21.0	17.4	8.6	2.3	0.4	0.0	0.0		100

Chapter 3: Design Requirements

- Design Cruise Ship
- Structural Requirements
- Functional Requirements
- Nautical Requirements

Chapter 5: Floating Structures in General

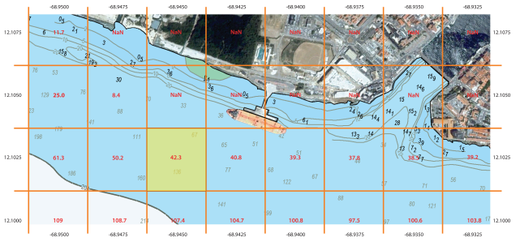
Theory + Background Information

- Why and why not Floating?
- Structure Types
- RAO's and Response Spectra
- -Stability and Motion Criteria

Chapter 4: Simulations with SWAN

What is the local wave climate at the suggested project location?

Computational Model + Output Location



Input scenarios for Wind Waves (& Swell):

Wind Sea Waves #	Hs [m]	Tp [s]	θ [°]	σ_θ [°]	u_10 [m/s]	u_10d [°]	Pr,θ [%]
W1A	0.6	5.2	80	30	5.8	80	*
W2A	1.2	5.2	80	30	7.7	80	*
W2B	1.2	6.9	80	30	7.4	80	*
W2D	1.2	5.2	70	30	7.8	70	*
W2E	1.2	5.2	90	30	7.8	90	*
W3A	1.8	6.3	80	30	9.4	80	*
W3C	2.7	6.9	80	30	11.7	80	*

Significant Wave Height [m]	Wave Peak Period [s] 3.2	3.6	3.9	4.3	4.7	5.2	5.7	6.3	6.9	7.6
0 - 0.3	326	195	96	-	-	-	-	-	-	-
0.3 - 0.6	1060	1480	1220	756	359	128	-	-	-	-
0.6 - 0.9	-	377	1412	3302	3042	1586	516	110	-	-
0.9 - 1.2	-	-	64	785	3513	5372	3106	774	165	62
1.2 - 1.5	-	-	-	-	414	3421	5177	2694	574	122
1.5 - 1.8	-	-	-	-	-	320	3110	3726	1210	172
1.8 - 2.1	-	-	-	-	-	-	316	2486	1589	332
2.1 - 2.4	-	-	-	-	-	-	-	349	1179	366
2.4 - 2.7	-	-	-	-	-	-	-	-	240	208
2.7 - 3.0	-	-	-	-	-	-	-	-	-	75
	3.2	3.6	3.9	4.3	4.7	5.2	5.7	6.3	6.9	7.6

Conclusion: Key Scenarios representing the local wave climate near Willemstad

Wind Sea Waves #	Hs [m]	Tp [s]	σ_θ [°]	u_10 [m/s]	θ_w [°]	Pr,θ [%]
W2B	1,2	6,9	30	7,4	80	26.4
W3A	1,8	6,3	30	9,4	80	4.2
W3C	2,7	6,9	30	11,7	80	0.1

Swell Waves #	Hs [m]	Tp [s]	σ_θ [°]	u_10 [m/s]	θ_w [°]	Pr,θ [%]
S1C	0,3	16,3	15	5,6	70	58.6
S2E	0,9	11,2	15	6,6	70	13.6
S3A	1,5	11,2	15	7,5	70	1.4
S3C	2,1	8,4	15	9,2	70	0.1

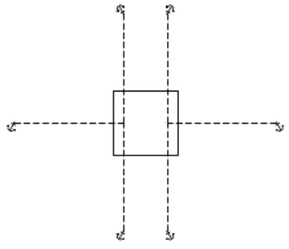
Chapter 6: General Design Considerations

Terminal Variants: Model A - 30x30m pontoon
Model B - 80x30m pontoon
Design Cruise ship: Model C - Oasis of the Seas

	Length L_f [m]	Width W_f [m]	Height D_h [m]	Draught D_d [m]	Mass m_f [m]	Water Displacement V_w [m^3]	Mass Moment of inertia I_{xx} [t m^2]	I_{yy} [t m^2]
Model *A*	30	30	5	2.53	2.53	$2.3 \cdot 10^3$	265021	265021
Model *B*	80	30	5	2.50	6.150	$6.1 \cdot 10^3$	639166	3421486

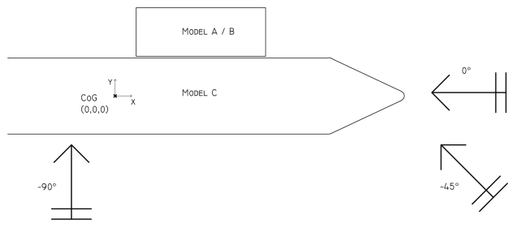
Anchorage:

- Catenaries
- Weight Blocks



Alignment Angles:

- 0 degrees
- 45 degrees
- 90 degrees



Chapter 7: Simulations with AQWA

What is the motion response of Models A and B?
What is the influence of a cruise ship next to the terminal?

IN → **OUT**

Geometry of Terminal Structures
Regular Wave Environment
Constant Parameters
→ AQWA-LINE → *Radiation/Diffraction Motion Analysis:* **FFRAO** *Hydrodynamic Database*

Anchorage
Local Wave Spectra
→ AQWA-LIBRIUM → *Natural Frequencies Motion Analysis:* **RAO** *Equilibrium Configuration*

Geometry of Cruise Structure
Post-Processing Results
→ AQWA-FER → *Coupled and uncoupled Motion Analysis:* **Response Spectra**

Result:
Free Floating RAO, RAO and Response spectra of:

Model A *Model B*
Model C+A *Model C+B*

for:

Accelerations: *in x-direction* *in y-direction* *in z-direction*
Displacements: *about x-axis* *about y-axis*
Alignment angles: *0°* *45°* *90°*

Chapter 8: Downtime Assessment

Do the models exceed motion criteria?
What is the downtime of the models?

Acceleration in Z-Direction	0 deg	45 deg	90 deg		0 deg	45 deg	90 deg
S1C	3,0E-03	1,7E-03	6,9E-03	S1C	2,9E-03	1,3E-03	3,6E-03
S2E	1,1E-02	5,3E-03	2,3E-02	S2E	1,1E-02	5,9E-03	1,2E-02
S3A	2,3E-01	7,8E-02	3,2E-01	S3A	1,9E-01	4,1E-02	6,5E-02
S3C	1,0E-01	4,6E-02	1,9E-01	S3C	9,9E-02	6,4E-02	8,5E-02
W2B	1,8E-01	6,6E-02	2,2E-01	W2B	1,5E-01	4,0E-02	6,8E-02
W3A	3,6E-01	1,3E-01	5,1E-01	W3A	3,1E-01	1,0E-01	1,6E-01
W3C	6,1E-01	2,3E-01	8,6E-01	W3C	5,3E-01	1,6E-01	2,1E-01

- *Calculated RMS-values for the indicated motions and wave angles*
- *Compared with the Nordforsk Criteria for:*
  - *Cruise Liners (= Green)*
  - *Transit Passengers (= Orange)*

Chapter 9: Conclusion

For these specific floating terminals studied, the realisation is only feasible in specific cases:
- *Model C+B leads to the lowest downtimes:*
  - *at most 0.1% for swell wave scenarios,*
  - *at most 1.4% for wind sea wave scenarios,*

in case of an alignment angle of 45° relative to the dominant wave angle.
- *Heave accelerations are in all cases the limiting factor that results in downtime.*
- *Recommendation: Optimizing the pontoon geometry and the mooring system will most likely lead to a reduction of heave accelerations, greatly improving the potential of this concept.*