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Analyzing the impact of various geometries on the operability of crew transfer vessels

1. Introduction

- Crew Transfer Vessels (CTVs) are integral to offshore operations in diverse industries.
- CTVs specialize in transporting personnel and equipment to offshore sites, including wind farms.
- Their significance lies in ensuring efficient and safe operations in remote marine environments.
- The offshore wind industry's rapid growth underscores the increasing importance of CTVs.
- This study focuses on assessing CTV operability and seakeeping abilities to optimize performance.
- Through a comprehensive analysis methodology and simulation in the North Sea, the research aims to provide valuable insights for stakeholders.

2. Background

2.1 Crew Transfer Vessels

Overview:

- CTVs typically range from 12m to 24m in length and accommodate an average of 12 passengers per trip, along with essential equipment.
- The catamaran hull form is commonly used in CTV designs, although other hull forms like SWATH are also employed.
- This report focuses on investigating the catamaran hull form in the context of CTV operations.

Image credit: https://en.wikipedia.org/wiki/Crew_boat#/media/File:Offshorecrewboat.jpg

2. Background

2.1 Crew Transfer Vessels

Market dynamics:

- The CTV market has experienced significant growth in the past decade, leading to the evolution of vessel designs driven by demand and competition.
- Larger vessels have become prevalent, offering increased crew capacity and fuel efficiency, thereby setting new standards in the industry.
- Newer vessels prioritize fuel efficiency through lightweight materials like glass reinforced pla ... rer's requirements for cost-effective o...

Image credit: https://www.commercialribcharter.co.uk/blog/summer-campaign-crew-transfer-vessels/

2. Background

2.1 Crew Transfer Vessels

<u>Competitive landscape</u>:

- Despite the emergence of alternative transfer methods such as Service Operational Vessels and helicopters, CTVs remain popular due to their cost-effectiveness.
- Smaller companies entering the market often opt for CTVs due to their affordability compared to helicopters.
- The study aims to identify the optimal geometry of a CTV to ensure seamless performance under limiting criteria, enhancing operator confidence and maintaining the vessel's popularity.

Image credit: https://www.bbc.co.uk/news/science-environment-62731923

2. Background

2.1 Crew Transfer Vessels

Operational challenges:

- Adverse weather conditions can disrupt offshore operations, leading to potential workdays lost.
- Research into environmental factors and tailored vessel geometries can enhance operability and minimize disruptions at fixed offshore sites.
- While helicopters offer advantages in accessibility and shorter maintenance trips, their higher costs make CTVs a more economical choice for many operators.

2. Background

2.2 Offshore wind farms

- The project focuses on simulating conditions similar to the Hornsea One offshore wind farm, the world's largest, located in the southern North Sea off the Yorkshire Coast.
- Wave scatter diagrams and long-term statistics from the proposed site inform operational assessments and simulations.
- The project methodology is adaptable for assessing vessel geometries in various offshore environments to identify optimal d

m	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20
0-0.5	331	3	103	1713	4038	1445	809	752	638	444	252	128	146	206	183	133	100	28	8	4
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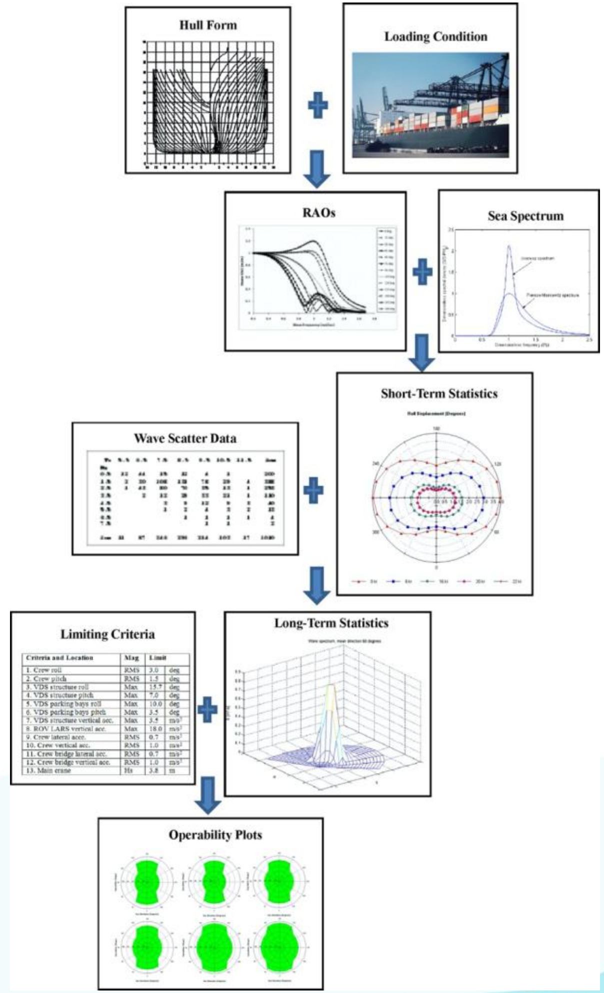
1-1.5	0	0	1	304	9696	5400	3406	2254	1053	1054	781	303	136	39	14	1	1	1	1	0
1.5-2	0	0	0	1	2472	8968	3287	1815	966	590	521	378	148	31	3	1	4	1	0	0
2-2.5	0	0	0	0	54	4472	3752	1570	722	404	267	264	144	44	4	1	3	0	0	0
2.5-3	0	0	0	0	1	903	3307	1650	567	328	155	128	75	42	4	2	0	0	0	0
3-3.5	0	0	0	0	0	22	1409	1617	513	294	105	56	42	13	3	2	0	0	0	0
3.5-4	0	0	0	0	0	0	241	999	525	297	107	31	22	2	1	1	0	0	0	0
4-4.5	0	0	0	0	0	0	9	396	350	227	82	36	9	8	3	0	0	0	0	0
4.5-5	0	0	0	0	0	0	0	100	157	145	90	43	10	2	1	0	0	0	0	0
5-5.5	0	0	0	0	0	0	0	34	36	83	63	52	4	3	0	0	0	0	0	0
5.5-6	0	0	0	0	0	0	0	2	13	26	50	26	8	7	0	0	0	0	0	0
6-6.5	0	0	0	0	0	0	0	0	5	5	7	16	2	2	0	0	0	0	0	0
6.5-7	0	0	0	0	0	0	0	0	1	0	0	11	4	1	0	0	0	0	0	0
7-7.5	0	0	0	0	0	0	0	0	0	0	0	0	5	4	0	0	0	0	0	0
7.5-8	0	0	0	0	0	0	0	0	0	0	0	0	4	1	0	0	0	0	0	0

2. Background

2.3 Operability

- CTV missions involve two critical phases: transit and transfer, each requiring separate operability calculations.
- Ensuring safety and comfort during transit is vital for crew and passenger well-being and operational efficiency.
- Operability analysis involves assessing vessel geometry, seaway definition, and limiting criteria as outlined by Tezdogan et al. [4].
- During transfer, the vessel acts as a floating structure, requiring different limiting criteria to ensure safe movement.



3. Methodology

- MAXSURF Modeller is utilized for CTV geometry generation, providing tools for hull modelling and motion prediction.
- A basic catamaran model serves as the basis for scaling geometries ranging from 16m to 30m in length, ensuring consistent simulations.
- The table on the right presents the basic characteristics of each CTV geometry investigated in the study.

	Catamaran Lengths							
	16m	18m	20m	22m	24m	26m	28m	30m
Length (L_{BP}) (m)	15.23	17.60	19.03	20.94	22.84	24.75	26.65	28.55
Overall beam (B_{OA}) (m)	4.605	5.180	5.755	6.326	6.911	7.482	8.061	8.635
Beam of demi-hull (B_{DH}) (m)	0.46	0.52	0.58	0.63	0.69	0.75	0.81	0.86
Draught (T) (m)	0.46	0.52	0.578	0.635	0.69	0.751	0.81	0.87
Displacement (Δ) m^3	3.940	5.640	7.751	10.253	13.504	16.996	23.266	26.238
Long. Center of gravity (LCG) aft of amidships (m)	6.08	6.94	7.71	8.51	9.32	10.08	10.95	11.62
Vertical center of gravity (VCG) (m)	1.49	1.68	1.87	2.05	2.24	2.43	2.61	2.8
Roll radius of gyration (r_{44}) (m)	0.54	0.61	0.68	0.75	0.82	0.89	0.95	1.02
Pitch radius of gyration (r_{55}) (m)	3.94	4.4	4.93	5.38	5.73	6.40	6.84	7.39

3. Methodology

- Calculating a vessel's operability index involves considering its motion characteristics, environmental conditions, and limiting criteria using ShipX VERES.
- Tables 3 and 4 outline the limiting criteria for the transit and transfer phases, respectively, including parameters such as vertical and horizontal accelerations, roll, pitch, motion sickness incidence, and motion-induced interruptions.

Table 3: Limiting criterion for transit phase

Criteria	Value	Location	Reference
Vertical acceleration, Root Mean Square (RMS)	0.15g	Fore Peak (FP)	[8]
Roll, RMS	6.0deg	Center of gravity	[22]
Pitch, RMS	4.0deg	Center of gravity	[22]
Motion Sickness Incidence (MSI)	20% in 2 hours	Accommodation	[8]
Motion Induced Interruptions (MII)	1 per minute	Accommodation	[18]
Slamming	10 per hour	FP	[8]

Table 4: Limiting criterion for transfer phase

Criteria	Value	Location	Reference
Vertical acceleration, RMS	0.05g	FP	[8]
Horizontal acceleration, RMS	0.04g	FP	[22]
Roll, RMS	2.5deg	FP	[21]
Pitch, RMS	2.0deg	FP	[21]

4. Results

- Eight CTV geometries ranging from 16m to 30m were subjected to operability analysis to determine the best-performing geometry.
- A consistent pattern emerges across results, indicating lower operability percentages at wave headings of 60°, 90°, and 120°, particularly at 90° due to specific hull design characteristics.
- Narrow demihulls and large separation between hulls contribute to increased wave-induced motions at certain wave headings, impacting operability.

Table 5: Operability indices (%) for independent wave headings at both phases for each CTV geometry

	Ship speed													
	0 knots							**24 knots**						
	Wave headings													
	0°	**30°**	**60°**	**90°**	**120°**	**150°**	**180°**	**0°**	**30°**	**60°**	**90°**	**120°**	**150°**	**180°**
16m	97	99	46	20	55	100	98	100	100	97	48	100	99	100
18m	98	100	50	18	65	100	99	99	100	99	47	100	100	100
20m	98	100	47	18	63	100	99	100	100	100	74	100	100	100
22m	99	100	46	16	66	100	99	100	100	100	54	100	100	100
24m	99	100	42	15	57	100	99	100	100	100	60	100	100	100
26m	99	100	42	15	58	100	99	100	100	100	67	100	100	100
28m	99	100	35	14	43	100	99	100	100	100	73	100	100	100
30m	99	100	39	15	56	100	99	100	100	100	53	100	100	100

4. Results

- The 20m CTV provides the best operability of 85.80% closely followed by the 26m CTV. The 30m CTV provided the worst results with an average annual percentage operability of 81.68%. However, the results were very tight with only a difference of 4.12% between the highest and lowest percentage operability indices.
- No clear trend is observed between average percentage operability and ... plexity of factors influencing ope...

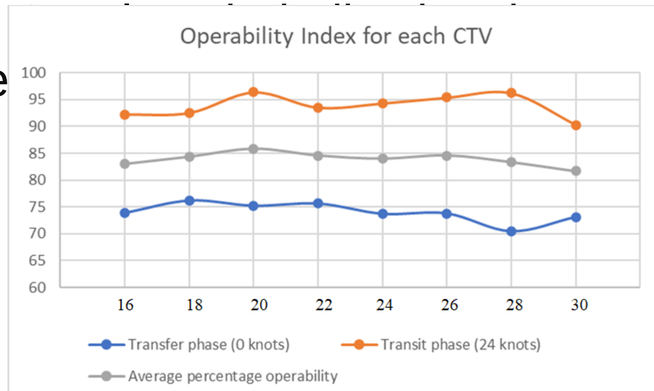


Figure 2: Average percentage operability indices (%) for each CTV (lengths are in meters)

5. Conclusions

Introduction:

- Growing importance of understanding efficiency factors in offshore operations, especially with the rise of CTV usage in offshore wind farms.

Methodology:

- Modelled eight CTV geometries (16m to 30m) using MAXSURF Modeller.
- Conducted operability analysis using VERES ShipX.
- Applied wave scatter diagrams and limiting criteria based on strip theory for analysis.

Optimal Geometry:

- Identified 20m CTV at Hornsea One offshore site as optimal, considering motion characteristics and safety criteria.

Valuable Methodology:

- Provides a valuable methodology for assessing vessel operability.
- Enhances understanding of passenger comfort, safety, and overall performance, crucial in the context of increasing CTV adoption in

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Thank You