Appendix

Websuit 1: The Protective Wetsuit for Olympic Foiling Sailors

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August 2nd 2021

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1. Observational research Almere (2 of 200 photos and 70 videos)

Matteo Sammarco, photo of iQFOiL crash

Matteo Sammarco, photo of iQFOiL foiling

2. Additional crash photos

born2sail, photo of Nacra17 crash

ttsailing, photo of Nacra17 crash

Rytis Jas, photo of iQFOiL crash

Casper Boumann, photo of IKA Formula Kite Crash

Casper Boumann, photo of IKA Formula Kite Crash

Sander de Kok, photo of IKA Formula Kite Crash

Sander de Kok, photo of IKA Formula Kite Crash

3. One-to-one interview guide

Research question: Investigate foiling sailors' mental and physical confidence when sailing in relation to their perceived personal safety.
Research sub-question: Analyze a particular dangerous event and evaluate how it has impacted the sailor both mentally and physically.
Research sub-question 2: Empathize on the awareness of the dangers of foiling and the actions sailors perform to keep themselves safe.
Disclaimer: I am from the Delft University of Technology and Sailing Innovation Center. I'm doing my graduation thesis on safety for foiling sailors, that is Nacra, IQFOIL and Formula Kite. Please do not disclose the questions of this interview with other people. I need your verbal consent to being recorded and using the information you provide for scientific research purposes, and academic publications and articles. No personal data outside the one you will share will be gathered. You can also choose to stay anonymous if preferred. Sensitive information such as boat regulations and procedures will not be shared outside of this study. Do you accept the aforementioned terms? Please state your name.
When did you start sailing?
Are you crew or helm?
Which role is more dangerous in your opinion?
Are you aware of the dangers you are exposed to when sailing?
Do you find foil strikes to be an impending risk for sailors?
How often does this thought cross your mind?
Are there times that you feel like you are taking too much of a risk, in terms of your physical safety?
There's a lot going on in maneuvers, do you feel like you can lose focus/control/limits and engage in risky behavior?
How does this impact your racing performance?

What goes through your mind when you know things are not gonna go your way?
What do you do on the boat to stay safe, give in some mainsheet?
How much does this impact your sailing performance?
Do you feel like if this barrier was broken, would you sail faster?
Specifically, if you felt safer, what would you actually do on the boat?
What would help you break this limit?
Respectfully, are you comfortable telling me about your worse accident?
Walk me through your feeling leading up to the incident.
Please think out loud for me
Has this incident impacted you physically?
For how long?
Has this mentally impacted the way you sail now?
Are you sailing slower because of that?
Is there a particular action you take to stay safe?
Do you feel like your safety is correctly advocated by everyone involved in your sport?
Do you feel like sailing brands such as Zhik, Magic marine and forward Wip provide enough safety solutions?
Are they provided by your sponsor?
How does the choice of what you wear depend on, temperature, conditions on the water?
What kind of personal protective equipment do you wear?
Do you like the current clothes you wear?
Do you always wear the same personal protective equipment?
Are you aware that forward Wip sells a cut protective suit?
(Optional) What does your ideal protection look like?
Bonus question! You haven't mentioned, your feet or hands, has the though of a foil strike to any of these ever crossed your mind?
This concludes my questions today. Is there anything I might have missed?
Would you recommend another person who would be interested in taking this same interview?
If you have additional comments, please reach out to me anytime. Thank you!

4. Incident reporting table

Number	Incident Date	Case Name	Boat Type	Status Comments
SP01	XX/09/17	29er Worlds capsize - trapeze hook entrapment	29er	Minimum age recommendation implemented for Youth Worlds. Submission 164-18 approved to implement quick release harness in RRS 43 from 1 January 2023.
SP02	01/12/2017	NACRA 17 - trapeze rope failure - rudder strike	NACRA 17	**Replacement trapeze line using poor quality rope.**
SP03	19/11/2017	Yacht - Clipper Race - crew overboard fatality	Clipper 70	**UK Marine Accident Investigation Branch Report Draft Circulated March 2019 - Safety Bulletin (SB1) Issued January 2018**
SP04	20/01/2018	Volvo Ocean Race: 'Vestas' collision - fishing boat crew member	Volvo Ocean 65	**Volvo Ocean Race commissioned independent investigation report issued 30 October 2018**
SP05	07/12/2017	Yacht - 'Tyger of London' - keel loss	Comet 45	**UK Marine Accident Investigation Branch-Safety Bulletin SB3 issued August 2018**
SP06	27/01/2018	NACRA 17-Miami SWC crew overboard - 'near-miss'	NACRA 17	**Incident reviewed and recommendations made to class.**
SP07	13/10/2017	Yacht - 'Prodigy 2' Keel loss - hull structural failure - crew ok	Yacht 60ft	**Polish Marine Accident investigation (PKBWM) Final Report issued March 2019**
SP08	04/02/2018	NACRA 17-racing - trapeze failure NZL Regatta	NACRA 17	trapeze failure where stainless steel hoop attached to block
SP09	05/01/2018	NACRA 17-training - gennaker hoist shoulder dislocation	NACRA 17	**Incident covered by previous recommendations. Panel to monitor further trends**
SP10	06/01/2018	NACRA 17-training - trapeze failure - rudder strike	NACRA 17	trapeze failure where stainless steel hoop attached to block

SP11	17/01/2018	NACRA 17 training - trapeze miss - rudder strike	NACRA 17	See NACRA 17 Class recommendations.
SP12	23/06/2017	49er racing - Kieler Woche excessive wind	49er	Race officials have the appropriate guidelines, authority and knowledge to decide on safe sea state and wind limits.
SP13	17/08/2017	NACRA 17- training - trapeze miss - rudder strike	NACRA 17	**Harnes was hooked into elastic, not trapeze loop**
SP14	01/11/2017	NACRA 17 first sail - pitchpole footstrap entrapment	NACRA 17	**See NACRA 17 Class recommendations.**
SP15	14/02/2018	NACRA 17 - foiling leeward side projected on to shroud	NACRA 17	Incident covered by previous recommendations. Panel to monitor further trends
SP16	22/02/2018	NACRA 17 - downwind deceleration - rudder strike	NACRA 17	**See NACRA 17 Class recommendations.**
SP17	23/02/2018	Yacht - 'Finistere' keel loss	Davidson 50ft	**RFBYC commisioned independent report and RFBYC response to recommendations published. Police report awaited.**
SP18	10/01/2018	Musto Skiff - Port-Starboard collision - Bowsprit hit helm's arm	Musto Skiff	Injured arm , RIB attended in 1 minute, Doctor on Committee Boat. Information has been sent to industry suppliers for potential development of protective clothing
SP19	15/02/2018	NACRA 17 -training - finger fracture bone	NACRA 17	**World Sailing Incident Report published**
SP20	20/03/2019	IMOCA 60 'Gonnagitcha 2' (ex 'Fleury Michon X' 1989) keel loss	IMOCA 60	Photo published of up-turned hull, no keel, bow sliced off. On passage north from Panama Canal - Caribbean . No further information
SP21	26/03/2018	Volvo Ocean Race 'Scallywag' MOB Fatality	Volvo Ocean 65	Awaiting Race Organisers report
SP22	15/04/2018	Crew overboard -Day race -yacht without guardrails 'Top Gun'	Adams 10	Sailing downwind, yacht broached crew fell overboard, after being recovered from the water the casuality could not be resuscitated
SP23	23/05/2018	Finn Masters - Faint	Finn (Masters)	Due to profile of participants, organisers developed emergency fast response procedure. Fire Brigade Rib with advanced health equipment arrived in 4 minutes.

SP24	23/06/2018	NACRA 17 Lake Garda bear away training	NACRA 17	**See NACRA 17 Class recommendations.**
SP25	07/04/2018	NACRA 17 - crew overboard training	NACRA 17	**See NACRA 17 Class recommendations.**
SP26	09/07/2018	NACRA 17 - rudder strike racing	NACRA 17	**See NACRA 17 Class recommendations.**
SP27	10/08/2018	Cowes Week - overboard crew dragged by spinnaker sheet	RS Elite	Crew fell overboard, dragged along by spinnaker sheet around leg
SP28	07/09/2018	NACRA 17-GBR - decelaration - shoulder injury	NACRA 17	**See NACRA 17 Class recommendations.**
SP29	18/09/2018	Kite-Fatality-non_racing French male 45-Siciliy	Kiteboard	Outside Scope - non-racing and non-race training
SP30	30/06/2018	Kite-Fatality-non_racing-collision Italian male 31-Sicily	Kiteboard	Outside Scope - non-racing and non-race training
SP31	12/09/2018	Kite-Fatality-non_racing-Polish male-Sicily	Kiteboard	Outside Scope - non-racing and non-race training
SP32	12/09/2018	NACRA 17 crew overboard - rudder strike	NACRA 17	**See NACRA 17 Class recommendations.**
SP33	25/09/2018	Kite-Fatality-non_racing-Galicia_Spain	Kiteboard	Outside Scope - non-racing and non-race training
SP34	29/05/2018	Kite-Fatality-non_racing-Porto Seguro_Brazil	Kiteboard	Outside Scope - non-racing and non-race training
SP35	26/10/2018	NACRA 17 deceleration, crew hit something on deck with ankle	NACRA 17	**See NACRA 17 Class recommendations.**
SP36	14/09/2018	Kite collision with Umpire Jetski	Kiteboard TwinTip:R	Umpire/Safety Jetski collided with competitor, transferred to ambulance in 5 minutes of incident.
SP37	17/01/2019	NACRA 17 - Helm fell overboard during gybe - legs hit rudder	NACRA 17	**See NACRA 17 Class recommendations.**

SP38	21/02/2019	NACRA 17 - Accidental trapeze un-hook, rudder strike armpit	NACRA 17	**See NACRA 17 Class recommendations.**
SP39	30/04/2019	NACRA 17 - Helm Crew collide	NACRA 17	**See NACRA 17 Class recommendations**
SP40	12/06/2019	RS Venture - capsize - Fatality	RS Venture	Capsize and full inversion of self-righting keelboat RS Venture Connect sail number 307 with loss of 1 life - GOV.UK (**www.gov.uk**)
SP41	25/08/2019	NACRA 17 - Japan collision rudder strike	NACRA 17	**See NACRA 17 Class recommendations**
SP42	10/05/2019	SLED - crew cardiac arrest	TP52	
SP43	25/08/2019	Provezza - Dismasting head injury	TP52	
SP44	23/09/2019	Phoenix II - Winch pedestal - broken arm	TP52	
SP45	29/09/2019	Windfoiling - missed wishbone, foil strike	Windfoiling	
SP46	30/05/2019	Collision with hydrofoil ferry - fatality	RS:X	
SP47	30/08/2019	49erFX FIN Back injury	49erFX	
SP48	04/04/2019	NACRA 17 - foil strike	Nacra 17	**See NACRA 17 Class recommendations**
SP49	09/01/2019	Tornado Towline	Tornado	
SP50	03/11/2019	Hugo Boss - keel collision	IMOC 60	Hugo Boss team report circulated
SP51	17/12/2019	Pinocchio - abandoned	Class 40	Skipper account published - Class 40 reviewed
SP52	05/01/2020	Showtime - keel detached	Ker 40 modified	Australian Sailing report pending
SP53	17/09/2020	iQFoil foil strike	iQFoil	

SP54	17/09/2020	Kiteboarding strike	Foiling Kite	
SP55	08/02/2020	crew fall and MOB - shoulder injury	M32	
SP56		Not used		
SP57	30/11/2020	PRB - IMOCA 60 structural failure	IMOCA	
SP58	02/12/2020	Initiatives Coeur - IMOCA 60 ufo keel collision	IMOCA	
SP59	25/11/2020	Optimist sailor fatality - unmanned RIB collision	Optimist	
SP60	17/01/2021	Patriot structural failure - swamping	AC75	
SP61	27/01/2021	SeaExplorer-Yacht Club de Monaco - collision	IMOCA	
SP62	23/02/2021	NACRA 17 - NOR rudder strike-leg cut	NACRA 17	**See NACRA 17 Class recommendations**

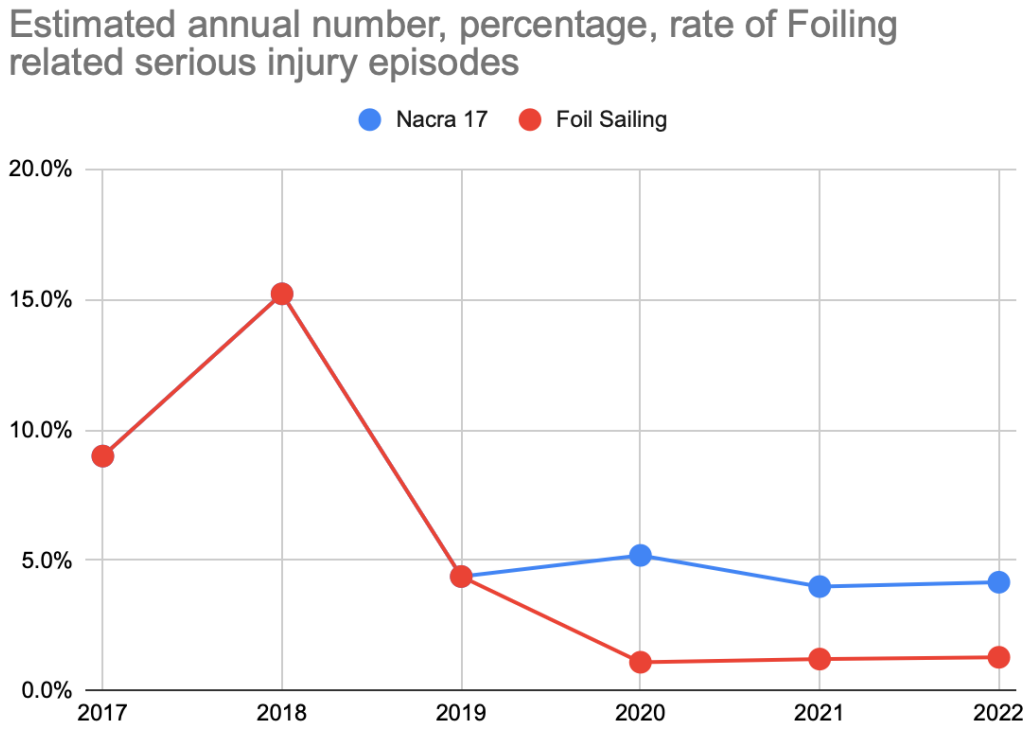
Evidence of injuries during an accident involving a foil strike

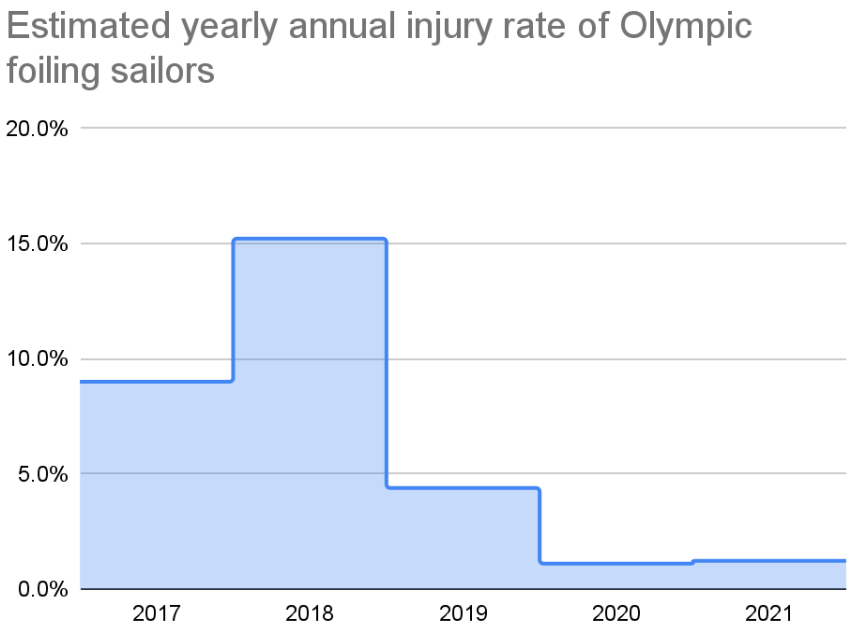
From the World Sailing incident reporting [2]:
Format: Case number: injury
SP11: Dented calf, pulled muscle, and bruising.
SP16: Left calf contusion, right ankle open wound laceration, no stitches required.
SP25: Open wound laceration and bruising on the inner side of the foot. Three series of stitches: two inside the skin and one on the surface (the last series with 12 stitches.
SP27: Significant bruising to hamstring, calf, and burn in back of the knee.
SP33: Deep, 30cm long cut along leg, calf muscle cut.
SP36: Penetrating wound in the inside part of the ankle, above the malleolus, five stitches required.
SP39: Arm swelling.
SP54: Deep cut in the right knee, below the patella, and significant loss of blood.
SP62: Deep and 10-15 cm long cut on the upper part of the leg. It required 21 stitches on the outside and additional stitches on the inside.

The time of recovery for these injuries range from two weeks and upwards of three months.

5. Incident reporting statistics

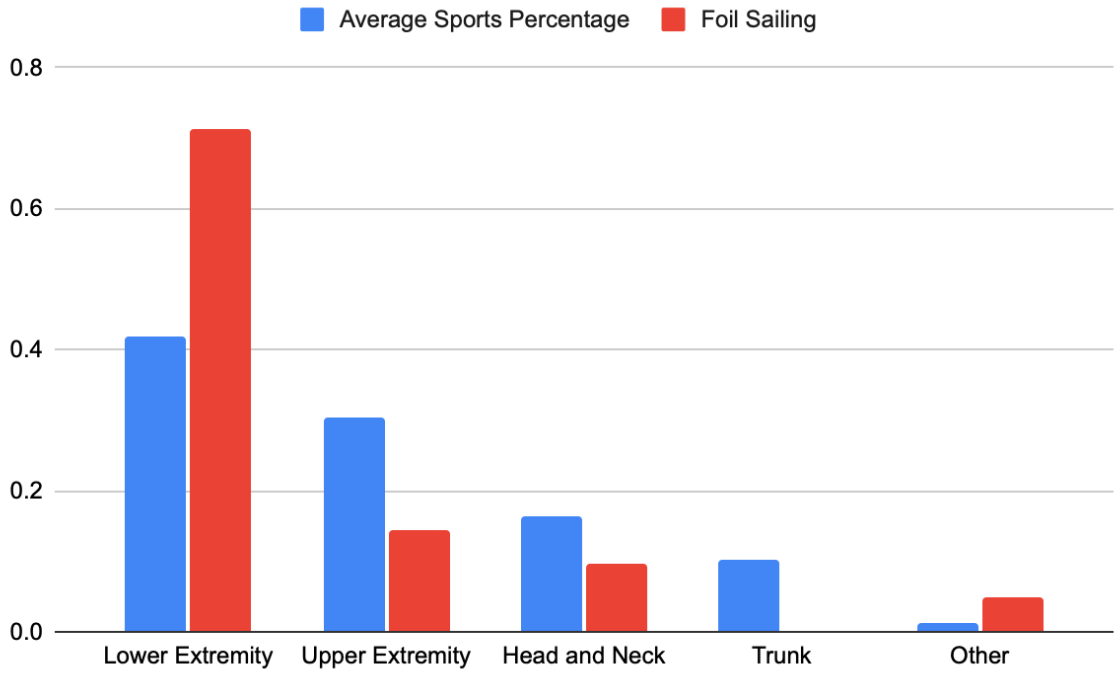
	Nacra 17			iQFOiL			Formula Kite			Total		
Year	Number of active sailors	Number of serious injuries	Injury rate %	Number of active sailors	Number of serious injuries	Injury rate %	Number of active sailors	Number of serious injuries	Injury rate %	Number of active sailors	Number of serious injuries	Injury rate %
2017	100	9	9.0%							100	9	9.0%
2018	92	14	15.2%							92	14	15.2 %
2019	114	5	4.4%							114	5	4.4%
2020	77	4	5.2%	450	3	0.67 %	200	1	0.5 %	727	8	1.1%
2021	100	4	4.0%	550	5	0.91 %	250	2	0.8 %	900	11	1.2%
2022	120	5	4.2%	688	7	0.98 %	313	3	0.9 %	1120	14	1.3%
Average	101	7	6.8%	562.500	4.917	0.87 %	254	1.9	0.7 %	509	10	2.01 %




Estimated yearly annual injury rate of Olympic foiling sailors
20.0%
15.0%
10.0%
5.0%
0.0%
2017
2018
2019
2020
2021

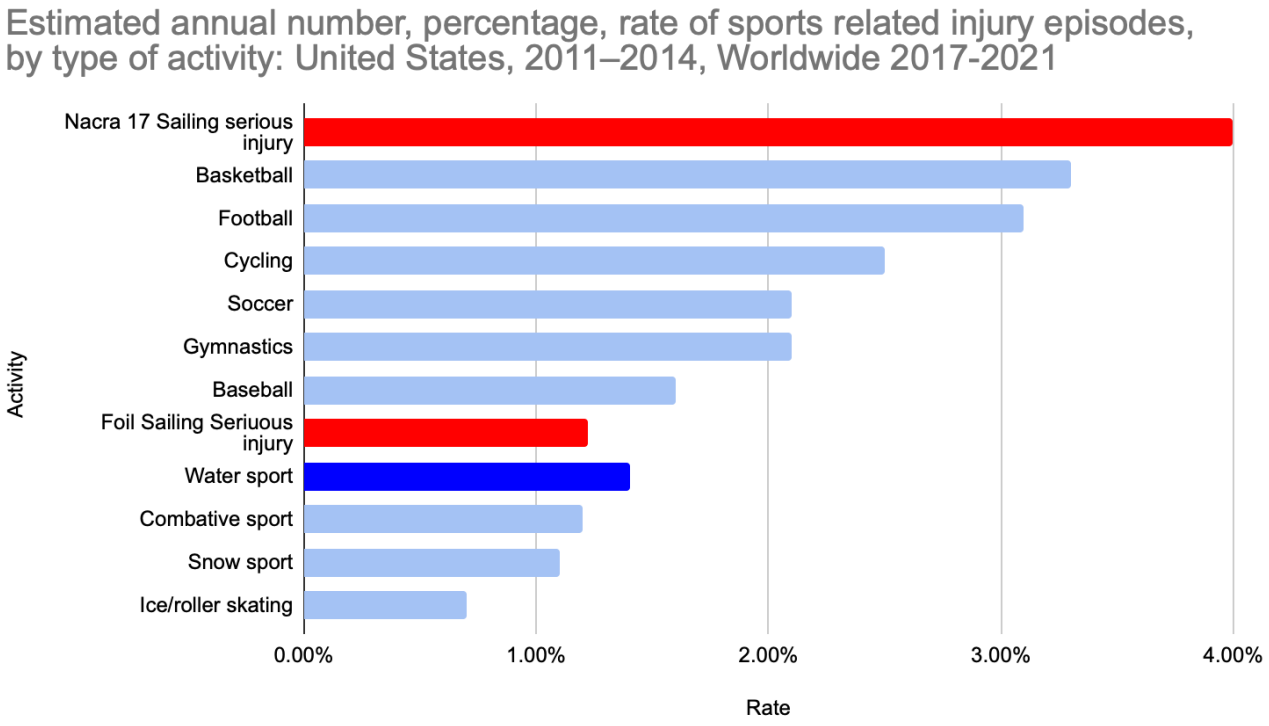
6. Injury location on body

Region	Average Sports Percentage	Foil Sailing Incidents	% of total
Lower Extremity	42.00%	15.00	71%
Upper Extremity	30.30%	3.00	14%
Head and Neck	16.40%	2.00	10%
Trunk	10.10%		
Other	1.20%	1.00	5%



7. Impact energy calculations

Activity	Rate
Nacra 17 Sailing serious injury	**4.0%**
Basketball	3.30%
Football	3.10%
Cycling	2.50%
Soccer	2.10%
Gymnastics	2.10%
Baseball	1.60%
Foil Sailing Seriuous injury	**1.2%**
Water sport	1.40%
Combative sport	1.20%
Snow sport	1.10%
Ice/roller skating	0.70%



8. Foil impact energy calculations

Nacra17

Total Mass (kg)	Wind speed (kn)	Boat speed (m/s)	Total kinetic energy (J)	Velocity after impact (m/s)	Average force (N)	Stress (Pa)	Decreased stress (Pa)
211	2	0.5	53	0.5	511	1	0
211	3	1.0	211	0.9	1021	1	1
211	4	1.5	475	1.4	1532	2	1
211	5	2.0	844	1.8	2043	3	1
211	6	2.5	1319	2.3	2553	3	2
211	7	3.0	1899	2.7	3064	4	2
211	8	3.5	2585	3.2	3575	4	2
211	9	4.0	3376	3.6	4085	5	3
211	10	4.5	4273	4.1	4596	6	3
211	11	5.0	5275	4.5	5107	6	3
211	12	5.5	6383	5.0	5617	7	4
211	13	6.0	7596	5.4	6128	8	4
211	14	6.5	8915	5.9	6639	8	4
211	15	7.0	10339	6.4	7149	9	4
211	16	7.5	11869	6.8	7660	10	5
211	17	8.0	13504	7.3	8171	10	5
211	18	8.5	15245	7.7	8681	11	5
211	19	9.0	17091	8.2	9192	11	6

211	20	9.5	19043	8.6	9703	12	6
211	21	10.0	21100	9.1	10213	13	6
211	22	10.5	23263	9.5	10724	13	7
211	23	11.0	25531	10.0	11235	14	7
211	24	11.5	27905	10.4	11746	15	7
211	25	12.0	30384	10.9	12256	15	8
211	26	12.5	32969	11.3	12767	16	8
211	27	13.0	35659	11.8	13278	17	8
211	28	13.5	38455	12.3	13788	17	9
211	29	14.0	41356	12.7	14299	18	9
211	30	14.5	44363	13.2	14810	19	9
211	31	15.0	47475	13.6	15320	19	10
211	32	15.5	50693	14.1	15831	20	10

iQFOiL

Total Craft Mass (kg)	Boat speed (m/s)	Total kinetic energy (J)	Velocity after impact (m/s)	Average force (N)	Stress (Pa)	Decreased stress (Pa)
91.3	0.5	23	0.4	460	6	3
91.3	1.0	91	0.8	921	12	6
91.3	1.5	205	1.2	1381	17	9
91.3	2.0	365	1.6	1841	23	12
91.3	2.5	571	2.0	2302	29	14
91.3	3.0	822	2.5	2762	35	17
91.3	3.5	1118	2.9	3223	40	20
91.3	4.0	1461	3.3	3683	46	23
91.3	4.5	1849	3.7	4143	52	26
91.3	5.0	2283	4.1	4604	58	29
91.3	5.5	2762	4.5	5064	63	32

91.3	6.0	3287	4.9	5524	69	35
91.3	6.5	3857	5.3	5985	75	37
91.3	7.0	4474	5.7	6445	81	40
91.3	7.5	5136	6.1	6906	86	43
91.3	8.0	5843	6.5	7366	92	46
91.3	8.5	6596	7.0	7826	98	49
91.3	9.0	7395	7.4	8287	104	52
91.3	9.5	8240	7.8	8747	109	55
91.3	10.0	9130	8.2	9207	115	58
91.3	10.5	10066	8.6	9668	121	60
91.3	11.0	11047	9.0	10128	127	63
91.3	11.5	12074	9.4	10589	132	66
91.3	12.0	13147	9.8	11049	138	69
91.3	12.5	14266	10.2	11509	144	72
91.3	13.0	15430	10.6	11970	150	75
91.3	13.5	16639	11.0	12430	155	78
91.3	14.0	17895	11.5	12890	161	81
91.3	14.5	19196	11.9	13351	167	83
91.3	15.0	20543	12.3	13811	173	86
91.3	15.5	21935	12.7	14272	178	89

IKA Formula Kite

Total Craft Mass (kg)	Boat speed (m/s)	Total kinetic energy (J)	Velocity after impact (m/s)	Average force (N)	Stress (Pa)	Decreased stress (Pa)
78	0.5	20	0.4	448	559922	279961
78	1.0	78	0.8	896	1119843	559922
78	1.5	176	1.2	1344	1679765	839883
78	2.0	312	1.6	1792	2239687	1119843
78	2.5	488	2.0	2240	2799608	1399804
78	3.0	702	2.4	2688	3359530	1679765
78	3.5	956	2.8	3136	3919452	1959726
78	4.0	1248	3.2	3583	4479373	2239687
78	4.5	1580	3.6	4031	5039295	2519648
78	5.0	1950	4.0	4479	5599217	2799608
78	5.5	2360	4.4	4927	6159139	3079569
78	6.0	2808	4.8	5375	6719060	3359530
78	6.5	3296	5.2	5823	7278982	3639491

78	7.0	3822	5.6	6271	7838904	3919452
78	7.5	4388	6.0	6719	8398825	4199413
78	8.0	4992	6.4	7167	8958747	4479373
78	8.5	5636	6.8	7615	9518669	4759334
78	9.0	6318	7.2	8063	10078590	5039295
78	9.5	7040	7.6	8511	10638512	5319256
78	10.0	7800	8.0	8959	11198434	5599217
78	10.5	8600	8.4	9407	11758355	5879178
78	11.0	9438	8.8	9855	12318277	6159139
78	11.5	10316	9.2	10303	12878199	6439099
78	12.0	11232	9.6	10750	13438120	6719060
78	12.5	12188	10.0	11198	13998042	6999021
78	13.0	13182	10.4	11646	14557964	7278982
78	13.5	14216	10.8	12094	15117885	7558943
78	14.0	15288	11.1	12542	15677807	7838904
78	14.5	16400	11.5	12990	16237729	8118864
78	15.0	17550	11.9	13438	16797650	8398825
78	15.5	18740	12.3	13886	17357572	8678786

9. Current wetsuits

Forward WIP protective long john (sailing)

Zhik Kollition suit (sailing)

Sailracing protective long john (sailing)

Chainmail wetsuit (scuba diving)

10. Photos of broken suit

11. Design requirements

The design requirements are arranged following four categories:
Use;
Performance;

Construction;
Standards;
Business;

1. Use

Requirements

1. The wetsuit shall provide users with a level of comfort consistent with the level of protection required against the hazard which is present, the ambient conditions, the level of the user's activity, and the anticipated duration of use of the protective clothing.
2. The wetsuit inspires confidence and trust in the user when wearing it.
3. The wetsuit will break at foil impacts above 10m/s, after which it must be replaced entirely.
4. The wetsuit motivates the purchase and regular use of protective equipment.

Wishes

1. The protection gear can be gently machine washed without damaging the structural integrity of the product.
2. The wetsuit inspires respect for the maritime ecosystem.
3. The wetsuit ensures sustainable consumption and production patterns.

1. Performance

Requirements

1. (Impact protection) The wetsuit should absorb at least 55% of the force applied from a foil strike at the average thickness.
2. (Impact protection) At the average thickness, the wetsuit should transfer the applied force to the body from a foil impact among a larger surface compared to current wetsuits of similar thickness.
3. The wetsuit should not break for foil impacts up to 10m/s.
4. (Slash protection) At the average thickness, the wetsuit should not tear when pressing a blade of a radius of curvature comparable to the trailing edge of a foil on it.
5. (Stretch) The wetsuit's material assembly should stretch in two perpendicular longitudinal directions (4-way stretch) to an extent comparable to wetsuits of equivalent thickness.
6. In each direction, the neoprene should stretch from at least 30% up to 100% of its' original length, depending on its position on the body.
7. (Abrasion resistance) The areas in front of the knees and the upper back of the legs should be of comparable abrasion resistance to current wetsuits.
8. (Heat transfer) The wetsuit's heat transfer properties are comparable to a conventional wetsuit of equivalent thickness.
9. (Durability) The wetsuit shall sustain regular use for up to 3 years.

1. Construction

Requirements

1. The wetsuit shall not have rough, sharp, or hard surfaces that irritate or injure the user; be so tight, loose, and heavy so that it restricts normal movement.
2. The wetsuit's protective layer should cover at least 80% of the wetsuit's surface.
3. The wetsuit's ankles and wrists should have silicone wrist seals to avoid flushes of water.
4. The wetsuit's total mass should not exceed 7kg when wet.
5. The wetsuit should have three holes of 3mm in diameter above the ankles to eject water surplus inside the suit.
6. The maximum thickness should be 3.5mm.
7. The wetsuit's seams must be glued, blind stitched & seam-sealed for complete waterproof protection, limiting heat transfer and maintaining flexibility.
8. The wetsuit's panel construction should be 3D-map-fitted to a p90 male and female in 6 different sizes for optimal comfort.

9. The outer material should accommodate graphic features such as shapes and colors through dyeing, embossing, or sewing.
10. The innermost lining should be a blend of Dyneema and nylon or similar for cut protection.
11. The panel around the neck should have low friction to allow easy entry.

Wishes

1. The Nacra17 wetsuit can be separated into two parts, a top, and a lower long john.
    a. The top should be worn by entering from the bottom to the top and should not have any securing mechanism.
    b. The bottom long john should be worn by entering from the top and be secured with a velcro strap on the right shoulder.
2. The iQFOiL and IKA Formula Kite should have a horizontal front zipper for front entry.
3. The male's wetsuit should have an opening on the crotch for urination.
4. The inner fleece should dry fast overnight in standard conditions.
5. The wetsuit should have an easy-access side pocket.
6. The yarn is made from recycled content, including plastic bottles, t-shirts and post-industrial scraps.
7. The foam layer of the neoprene is made from recycled content.
8. The product's aethetic features describe a story of performance and sustainability through patterns, colors and textures.

Standards

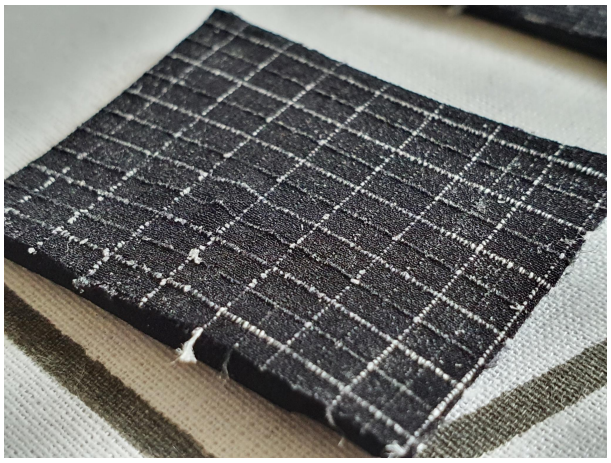
1. Any part of the wetsuit shall respect tolerated values in the ANSI/ISEA 138-2019 standard: American National Standard for Performance and Classification for Impact-Resistant Gloves.
2. The wetsuit should be tested in accordance with the ISO 13999-2:2003(en) standard: Protective clothing — Gloves and arm guards protecting against cuts and stabs by hand knives — Part 2: Gloves and arm guards made of material other than chain mail.
3. Alternatively to 4.2, the materials of the wetsuit shall respect the The European Standard for Protective Gloves, EN 388.

Business

1. The wetsuit has an unique selling point that distinguishes it from current wetsuits.
2. The buying price for the costumer of maximum €400.

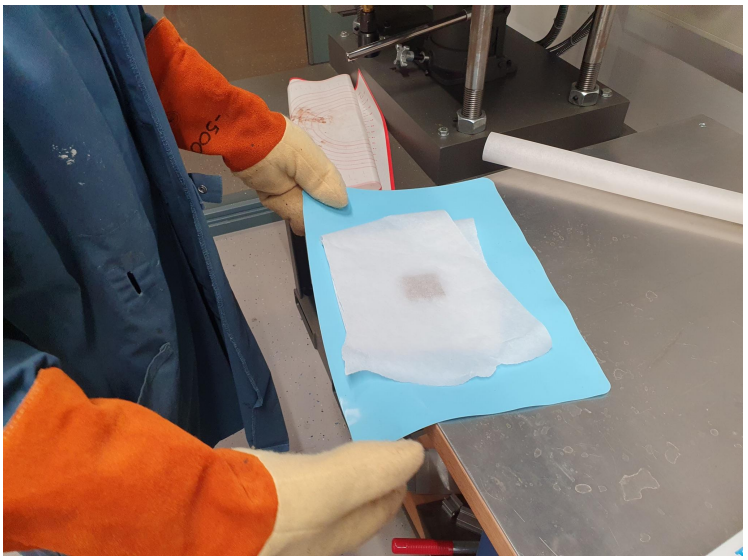
12. Additional prototyping photos

First prototypes with Vliesofix

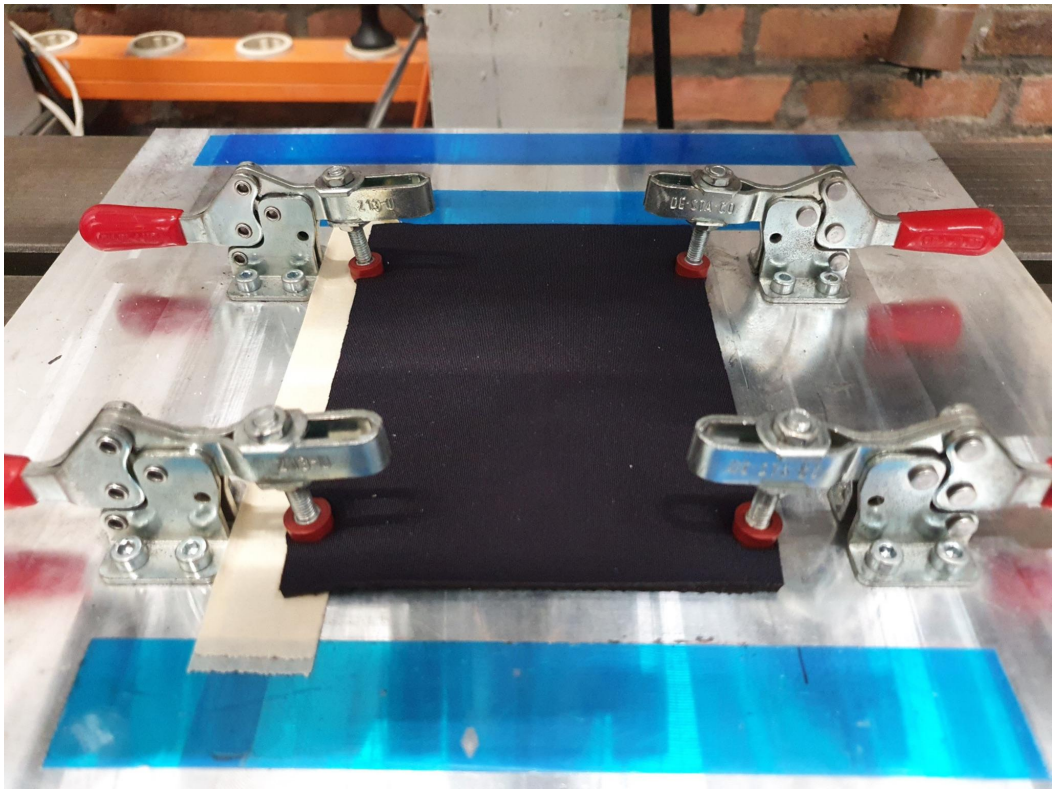


Preparing the polyurethane glue solution with activator

Heat press sample creation

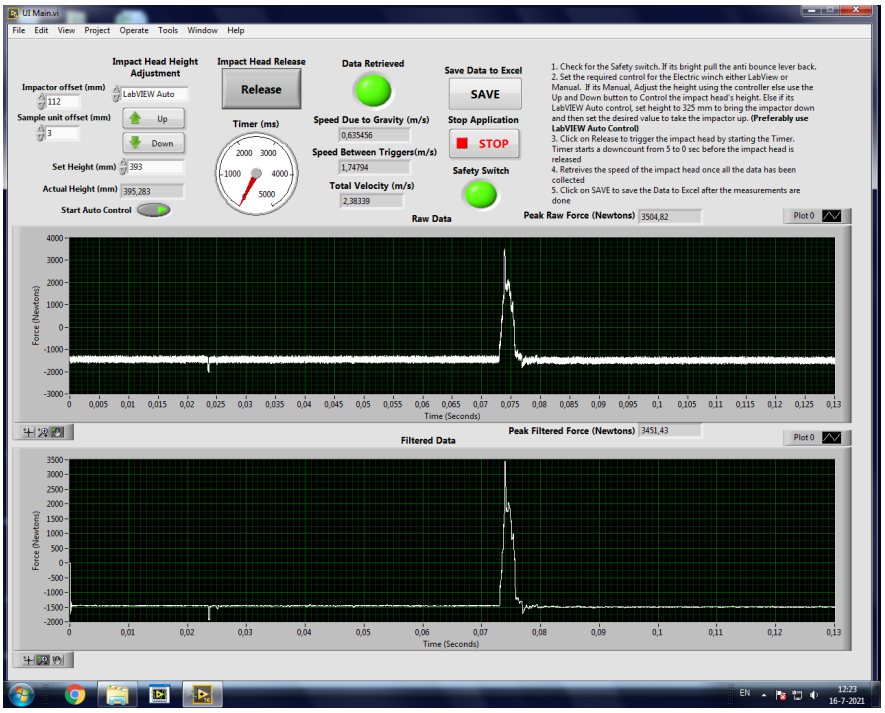


13. Impact tower setup photo

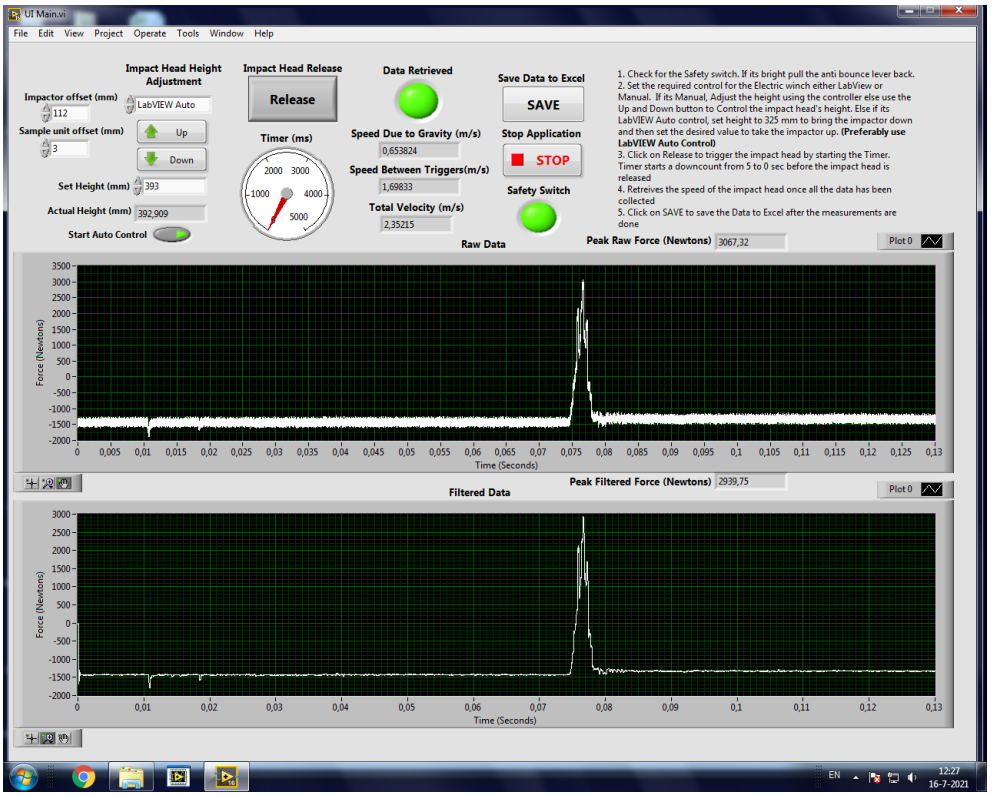


14. Impact tower measurements

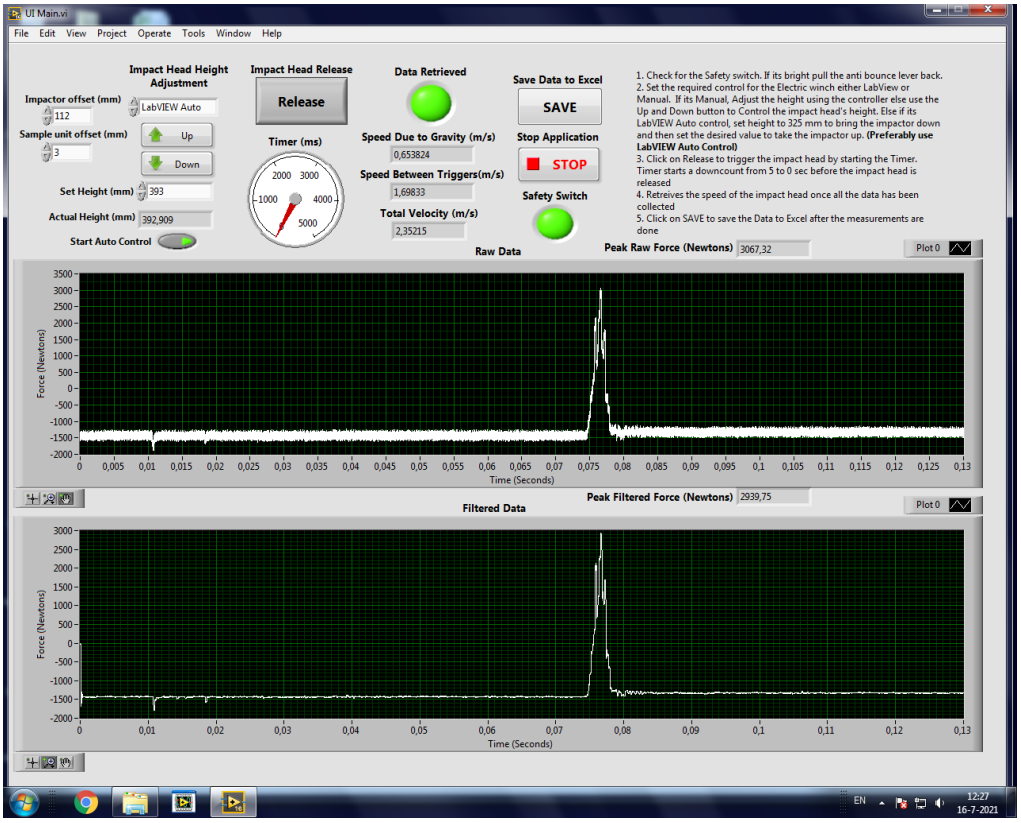
Screen capture of data from 40cm drop, 3mm aluminium sheet



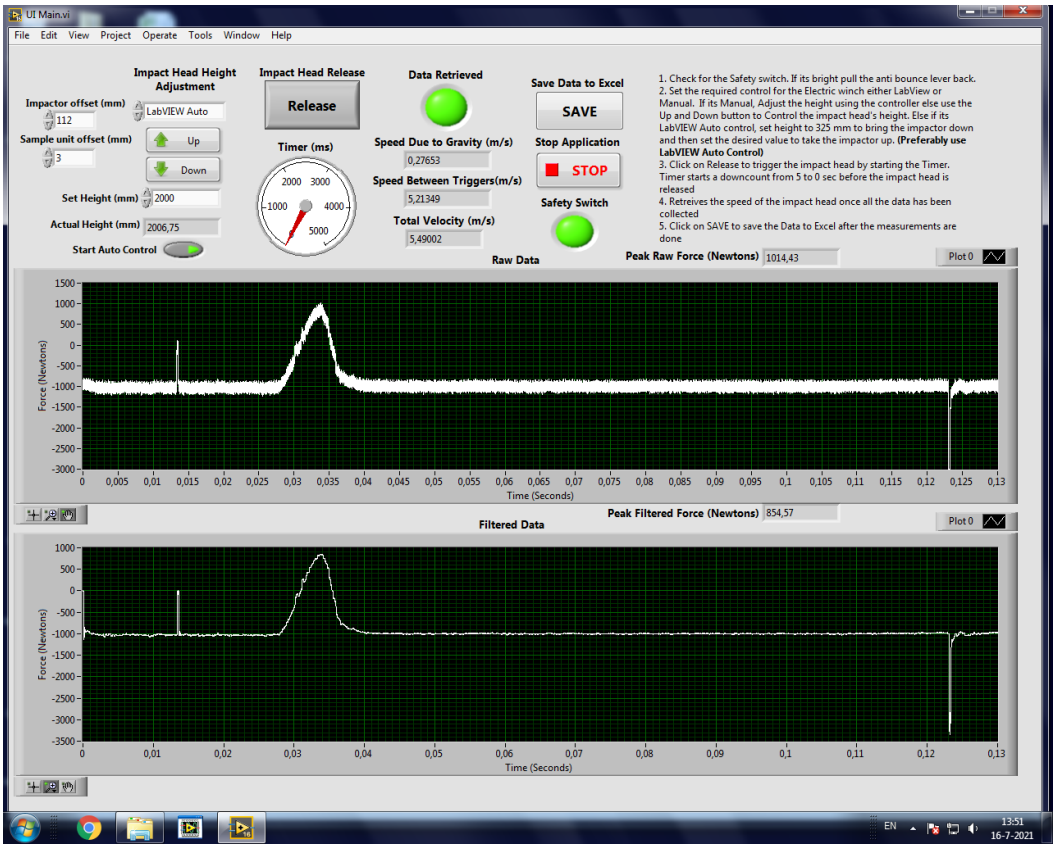
Screen capture of data from 40cm drop, 3mm aluminium sheet + lycra



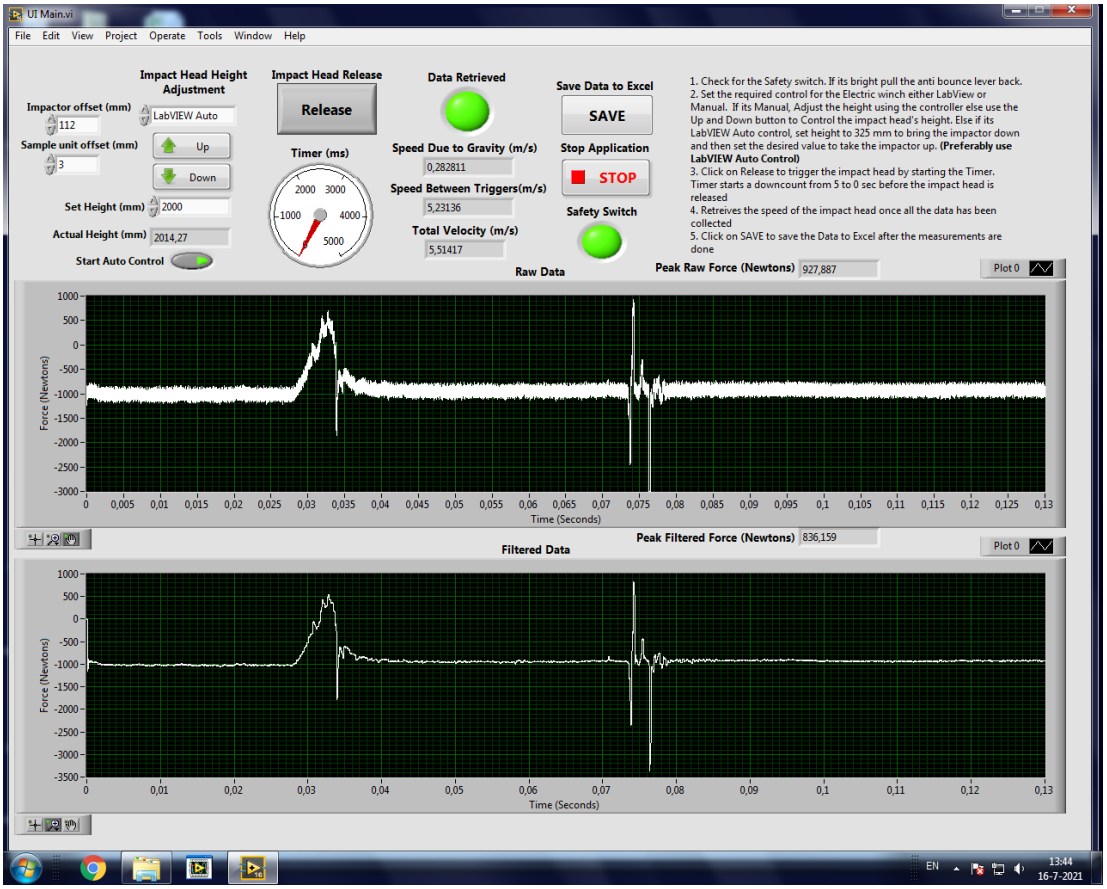
Screen capture of data from 40cm drop, 3mm aluminium sheet + lycra + 1mm GRDXKN



Screen capture of data from 2m drop, 3mm reinforced neoprene



Screen capture of data from 2m drop, 3mm reinforced neoprene



15. Impact tower sample damage

Conventional neoprene damage, 2m drop

Reinforced neoprene damage, 2m drop

16. Project brief

IDE Master Graduation

Project team, Procedural checks and personal Project brief

This document contains the agreements made between student and supervisory team about the student's IDE Master Graduation Project. This document can also include the involvement of an external organisation, however, it does not cover any legal employment relationship that the student and the client (might) agree upon. Next to that, this document facilitates the required procedural checks. In this document:

- The student defines the team, what he/she is going to do/deliver and how that will come about.
- SSC E&SA (Shared Service Center, Education & Student Affairs) reports on the student's registration and study progress.
- IDE's Board of Examiners confirms if the student is allowed to start the Graduation Project.

USE ADOBE ACROBAT READER TO OPEN, EDIT AND SAVE THIS DOCUMENT
Download again and reopen in case you tried other software, such as Preview (Mac) or a webbrowser.

STUDENT DATA & MASTER PROGRAMME

Save this form according the format "IDE Master Graduation Project Brief_familyname_firstname_studentnumber_dd-mm-yyyy".
Complete all blue parts of the form and include the approved Project Brief in your Graduation Report as Appendix 1 !

family name	Sammarco 4998
initials	MS given name Matteo
student number	
street & no.	
zipcode & city	
country	
phone	
email	

Your master programme (only select the options that apply to you):

IDE master(s):	★ IPD ○ DfI ○ SPD
2nd non-IDE master:	
individual programme:	- - (give date of approval)
honours programme:	○ Honours Programme Master
specialisation / annotation:	○ Medisign
	○ Tech. in Sustainable Design
	○ Entrepeneurship

SUPERVISORY TEAM **

Fill in the required data for the supervisory team members. Please check the instructions on the right !

** chair	dr ir. A.J. Jansen	dept. / section:	Sustainable Des. Eng.
** mentor	Lyè Goto	dept. / section:	Human-Centered Des.
2nd mentor	Inge de Zeeuw		
	organisation: Sailing Innovation Center		
	city: Den Haag	country:	The Netherlands

comments (optional)

Chair should request the IDE Board of Examiners for approval of a non-IDE mentor, including a motivation letter and c.v..

Second mentor only applies in case the assignment is hosted by an external organisation.

Ensure a heterogeneous team. In case you wish to include two team members from the same section, please explain why.

Procedural Checks - IDE Master Graduation

APPROVAL PROJECT BRIEF

To be filled in by the chair of the supervisory team.

chair dr ir. A.J. Jansen date 25 - 05 - 2021 signature ajansen Digitally signed by ajansen Date: 2021.05.25 12:19:24 +02'00'

CHECK STUDY PROGRESS

To be filled in by the SSC E&SA (Shared Service Center, Education & Student Affairs), after approval of the project brief by the Chair.
The study progress will be checked for a 2nd time just before the green light meeting.

Master electives no. of EC accumulated in total: nvt EC

Of which, taking the conditional requirements into account, can be part of the exam programme nvt EC

List of electives obtained before the third semester without approval of the BoE

Variant for Engineers

★ YES all 1st year master courses passed

○ NO missing 1st year master courses are:

name J. J. de Bruin date 26 - 05 - 2021 signature J. J. de Bruin, SPA Digitally signed by J. J. de Bruin, SPA Date: 2021.05.26 10:56:12 +02'00'

FORMAL APPROVAL GRADUATION PROJECT

To be filled in by the Board of Examiners of IDE TU Delft. Please check the supervisory team and study the parts of the brief marked **.
Next, please assess, (dis)approve and sign this Project Brief, by using the criteria below.

- Does the project fit within the (MSc)-programme of the student (taking into account, if described, the activities done next to the obligatory MSc specific courses)?
- Is the level of the project challenging enough for a MSc IDE graduating student?
- Is the project expected to be doable within 100 working days/20 weeks ?
- Does the composition of the supervisory team comply with the regulations and fit the assignment ?

Content: ★ APPROVED ○ NOT APPROVED

Procedure: ★ APPROVED ○ NOT APPROVED

- the projectbrief has been submitted much too late

comments

name Monique von Morgen date 08 - 06 - 2021 signature

Initials & Name MS Sammarco 4998 Student number 5036976

Title of Project Safety Design for Sailors of Foiling Classes

Personal Project Brief - IDE Master Graduation

TU Delft

Safety Design for Sailors of Foiling Classes — project title

Please state the title of your graduation project (above) and the start date and end date (below). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

start date 18 - 03 - 2021 — 30 - 07 - 2021 end date

INTRODUCTION **

Please describe, the context of your project, and address the main stakeholders (interests) within this context in a concise yet complete manner. Who are involved, what do they value and how do they currently operate within the given context? What are the main opportunities and limitations you are currently aware of (cultural- and social norms, resources (time, money,...), technology, ...).

This project is carried out with the Sailing Innovation Center's support and the TU Delft Faculty of Industrial Design Engineering. The Sailing Innovation Centre helps to accelerate innovations in sailing. The center supports the sporting ambitions of the Netherlands in sailing, promotes interest in sailing, and contributes to economic growth by supporting companies in realizing new and better products and services. The SIC is located in The Hague and is the Dutch Sailing Olympic team's home training base. This location allows for research and testing on the spot. The association closely collaborates with institutions and companies such as the Amsterdam Fashion Institute, the Dutch supplier of Dyneema, to facilitate technical research and prototype development.

Sailing safety is the study and practice of design, construction, and equipment to minimize boat collisions' occurrence and consequences involving sailboats. The project focuses on improving Dutch sailing athletes' safety of Olympic fast classes, such as the Nacra 17, a sailing hydrofoil, a sailboat with wing-like foils mounted under the hull. New boards, namely the QFoil (Windsurf) and Formula Kite (Kitesurf), are also equipped with hydrofoils and have recently been approved for the 2024 Summer Olympics. As these crafts increase their speed, the hydrofoils lift the hull/board up and out of the water, significantly reducing wetted area, resulting in decreased drag and increased speed. A sailing hydrofoil can achieve speeds exceeding twice the wind speed.

With the rise in popularity of new foiling classes, the average sailing speeds have significantly increased, and so have the risks of injuries. In the unlikely event of a crash, an out-of-control foiling sailboat/board and its components become dangerous to sailors and the others around them. An impact with a hydrofoil may cause severe skin lacerations, contusions, and bone fractures. Sailors are aware of these consequences, so they avoid taking risks and sail conservatively. Personal protective equipment should be the last line of defense against injury. However, due to the imminent dangers that foil sailors are currently exposed to and the lack of reliable personal protection, designers are urged to investigate new cut and impact protection options.

The suits now available on the market, manufactured by leading clothing companies Zhik and Magic Marine, are made for medium impacts inside the boats and do not account for extreme crashes involving direct contact with hydrofoils. These suits consist of conventional neoprene/fleece wetsuits combined with added plastic padding on the body's critically exposed areas, leaving other unprotected. General consumer sailors of different ages and expertise wear these suits and are considered the standard. Both these companies and other competitors lack a high-end suit for professional racing of the highest level that offers complete protection, thermal control, and comfort. Finally, no kind of protective footwear is available on the market today.

space available for images / figures on next page

Initials & Name MS Sammarco 4998 Student number 5036976

Title of Project Safety Design for Sailors of Foiling Classes

introduction (continued): space for images

image / figure 1: Kitefoiler crashing

image / figure 2: Kollition westuit by Zhik

PROBLEM DEFINITION **

Limit and define the scope and solution space of your project to one that is manageable within one Master Graduation Project of 30 EC (= 20 full time weeks or 100 working days) and clearly indicate what issue(s) should be addressed in this project.

The sailors' gear, customs, and habits are a delicate ecosystem, so introducing a new type of protective equipment should minimize its disturbance in exchange for the most significant benefit. Through innovation and integration, personal protective equipment should be the optimal configuration that maximizes protection, performance, and comfort. Excessively trading off one aspect for another is not ideal. For example, a thick metal shell effectively prevents foils' injury at the cost of the athlete's freedom of movement.

Sailors constantly put their gear to the test, exposing it to salty water, extreme temperatures, and wind. The brutal wear and tear that sailing gear is put through further constrain the solution space.
Hence, a holistic approach to the problem is essential for ensuring safety and creating a product that sailors desire to wear. Different perspectives are required, including engineering, ergonomics, and sailing experience.

ASSIGNMENT **

State in 2 or 3 sentences what you are going to research, design, create and / or generate, that will solve (part of) the issue(s) pointed out in "problem definition". Then illustrate this assignment by indicating what kind of solution you expect and / or aim to deliver, for instance: a product, a product-service combination, a strategy illustrated through product or product-service combination ideas, ... In case of a Specialisation and/or Annotation, make sure the assignment reflects this/these.

Investigate crashes and close-calls with foil sailors to research the mechanisms that cause injuries and develop a design solution to prevent this. The student should deliver a complete study of hydrofoil sailors' dangers and a design concept that improves their safety and confidence.

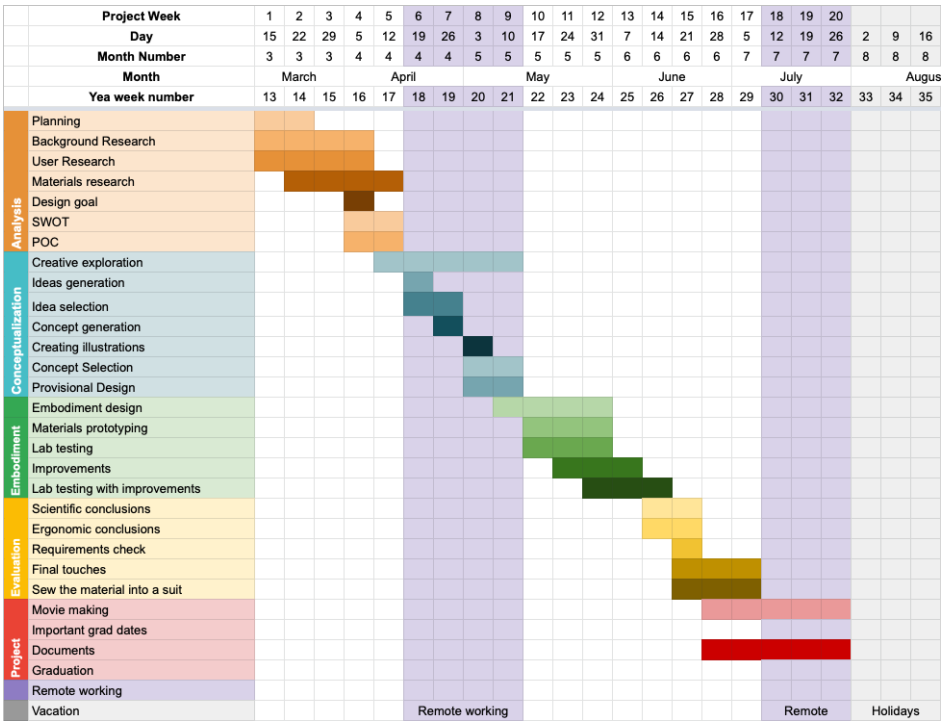
Initials & Name MS Sammarco 4998 Student number 5036976

Title of Project Safety Design for Sailors of Foiling Classes

PLANNING AND APPROACH **

Include a Gantt Chart (replace the example below - more examples can be found in Manual 2) that shows the different phases of your project, deliverables you have in mind, meetings, and how you plan to spend your time. Please note that all activities should fit within the given net time of 30 EC = 20 full time weeks or 100 working days, and your planning should include a kick-off meeting, mid-term meeting, green light meeting and graduation ceremony. Illustrate your Gantt Chart by, for instance, explaining your approach, and please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any, for instance because of holidays or parallel activities.

start date 18 - 3 - 2021 30 - 7 - 2021 end date



The graduation project is based on the double diamond design process. Similarly, the project plan is divided into four actionable design steps—Analysis, Conceptualization, Embodiment, and Evaluation.

In the Analysis phase, the student will perform user research on the field, read literature, and analyze existing footage of sailors crashing to define the design goal and list of requirements for the product. During Conceptualization, the student will explore and evaluate creative solutions for the design goal in light of the information previously discovered. The most promising concept will be selected and carried on to the Embodiment phase, where it will be improved thanks to testing and expert opinions. The final weeks are dedicated to the Evaluation phase, during which the student will select the most promising alternative based on the design requirements.

Eight hours of work are planned for every business day for twenty weeks, starting from week 13 until week 32 of 2021. Five festive days (on weekends and national holidays) per month are also planned for working on the project. The project is conducted while observing the health recommendations issued by the Dutch ministry of health: 1.5m distance, face mask, and remote working where possible. Remote working periods are shown in purple on the chart. The graduation ceremony is planned for July 31st if permitted by the faculty or the week of August 23rd.

Initials & Name MS Sammarco 4998 Student number 5036976

Title of Project Safety Design for Sailors of Foiling Classes

MOTIVATION AND PERSONAL AMBITIONS

Explain why you set up this project, what competences you want to prove and learn. For example: acquired competences from your MSc programme, the elective semester, extra-curricular activities (etc.) and point out the competences you have yet developed. Optionally, describe which personal learning ambitions you explicitly want to address in this project, on top of the learning objectives of the Graduation Project, such as: in depth knowledge a on specific subject, broadening your competences or experimenting with a specific tool and/or methodology, ... Stick to no more than five ambitions.

The key opportunity is to combine my engineering and design knowledge with my previous semi-professional sailing experience and provide an innovative solution for the Dutch Olympic sailors of the fast classes such as Nacra 17, Formula Kite, and IQFoil.

I have established expertise in Maths, Chemistry, Materials Science, Physics, Aerodynamics, and Hydrodynamics in my Engineering Sciences bachelor's degree. Thanks to this experience, I will approach material development and testing from a scientific point of view.

I will combine this with a creative approach thanks to my extensive knowledge in human-centric design and ergonomics that I have gathered so far in my Master's studies.

Finally, I will consolidate these two approaches with my experience as an Italian Sailing Team athlete and avid interest in sports. This also allows me to have conversations with athletes about particular topics easily and deeply understand boat-athlete interactions.

I am motivated to learn about textile materials: properties, manufacturing techniques, innovations, and applications. I am eager to design a niche product for top-level athletes and include them in the design process. I am excited to enter the foiling world, and I would like to gather as much practical and theoretical knowledge in foils. I am glad to have the opportunity to work in an outdoor environment that feels like home.

FINAL COMMENTS

In case your project brief needs final comments, please add any information you think is relevant.