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Influence Analysis of Deck Equipment Positioning on Performances in Sailing

Abstract

Authors in this paper presented the analysis regarding influence of deck equipment positioning and trimming, which is directly connected with sails, on sailing yacht performance in sailing. The analysis is performed by on-field measuring during sailing using specialized equipment based on RaceQs application and GPS support. The analysis is related to light wind conditions without significant waves, then to moderate wind and waves and finally to storm wind and high waves. Data collecting was performed during 30 hours of measuring and monitoring where the relevant equipment was continuously repositioned and trimmed aiming to reach more boat speed for different sailing angles. The results are processed and presented. The research was enabled with help and support of Bavaria Yachts d.o.o. Further analysis is suggested for different wind conditions and sea states.

Key words: Deck Equipment of small vessels, sailing yacht, RaceQs, GPS support

1. Introduction

An improvement in yacht design during last year's resulted in significantly enhanced performance of sailing vessels. However, growing competitiveness among designers has increased the demand for detailed experimental and computational research to better understand the behaviour of racing yachts and optimise their design and exploitation. Moreover, the operational complexity and performance requirements of modern racing yachts require the use of advanced applications [1].

Some applications are used for optimal selection of a mast and standing rigging [2] whereas others focus on the development of expert decision support systems for ship design [3]. Other contributions have addressed computer-aided design of ship systems automation [4, 5, 6 and 7].

In sailing the crew is "moving" the boat using large foils called sails. A sailor manages the force of the wind on the sails by adjusting the rigging in order to control the direction and speed of the boat. Sails are designed to be able to take the optimal shape

for all sailing conditions. To obtain the best sail shape, the crew adjust the traveller position and sail twist and camber. The fluid-structure interaction of sails and rigging is related to these manoeuvres.

The performance of the sail/rigging configuration can be analysed by two aerodynamic parameters, i.e. lift coefficient and drag coefficient. [8] Investigated the relation between changes in sail loads and in trim. The results showed that sail turn (change in traveller or jib car position) has an effect on lift and drag whereas camber has no influence on the former and only a slight influence on the latter. In order to study the behaviour of sails and rigging during navigation, it is necessary to consider all manoeuvrability variables. No software for operational computation of structure response to wind conditions considering variations in trim parameters introduced by the crew is currently available. One of the motivations of this work was the Bavaria Yachts team intention to investigate the influence analysis of such deck equipment positioning on sails shape i.e. on boats speed in sailing. The fleet of 20 identical sailing boats of Bavaria 40 S type are used for racing in Adriatic Sea. The significant differences in speed between different crews have been noticed. The goal was to create the guidelines for trimming the sails of these sailing yachts and put them on disposition for all crews. In such the way the speed differences in racing should be minimal and racing more closes and exciting i.e. faster.

2. Method and tools

For that purpose the large data collecting and analysis of deck equipment positioning regarding performances in sailing was performed. Data collecting was performed during 30 hours of measuring and monitoring using specialized tracking tools supported by GPS. The raceQs' tracker tool is used for monitoring and recording sailing data. This tool created a 3D replay of performed testing on the sea. The 3D replay showed the boat that has been recording in certain sailed area. Using such replay it is possible to learn the top performances of the tested boat. The raceQs' besides tracking also monitors and records the motion of the boat using the accelerometer and gyroscope in measuring equipment. Finally it is possible to evaluate boats tacking patterns, boat handling, heel angle, and more other data during testing in different wind and sea conditions and for different sailing angles.

Furthermore, the RaceQs' could be used for race analytics leading the crew to make correct choices in fleet racing. Such advanced analytics includes the tool that will analyze the boat handling. RaceQs stands out with an automatic wind detection algorithm, and a visual analytics dashboard. RaceQs Analytics Features:

- Create match-ups between any two boats
- Your Boat ranking at each mark
- Leg and Overall Statistics (Avg. and Max. speed, elapsed time, number of tacks)

- Tacking and Jibing Data (Time Lost, Duration, Tacking Angle)
- Boat Handling, Helm, and Driving (Groove Analysis)
- Wind Shadows
- Separation Distance Lines
- Multiple 3D and 2D Views
- Embedded comments and easy sharing

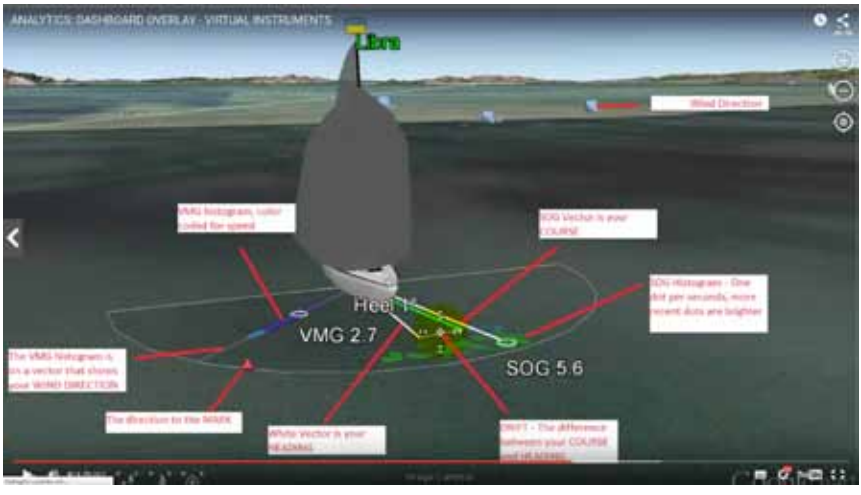

Figure 1. Screenshot of RaceQs tracking data explained

All the presented data was recorded during testing in different wind/wave conditions. For each wind/wave conditions the position of deck equipment i.e. *jib car* was combined from first extreme point to end extreme point as shown on figure 2.

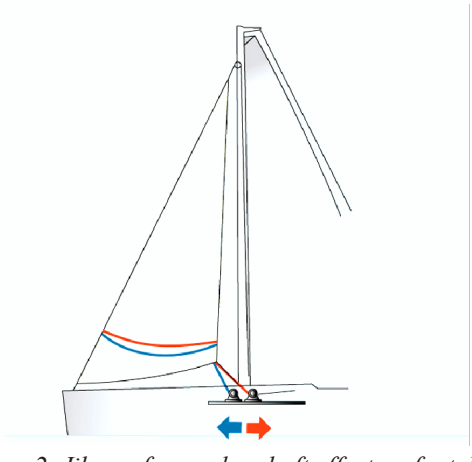

Figure 2. Jib car forward and aft effect on foot depth

The influence of such equipment positioning on leach sail shape is shown on figure 3.

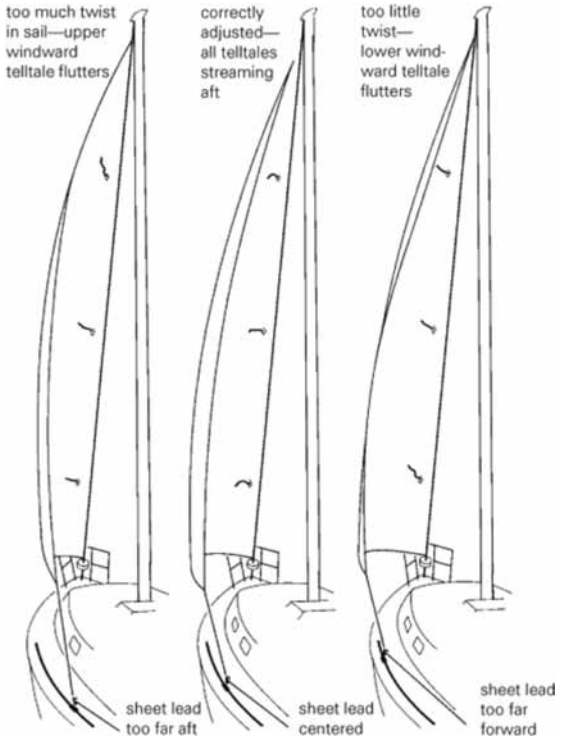

Figure 3. Jib car position vs leach shape

Different sail shape results in different lift/drag combination that directly influence the boat VMG speed.

3. Testing area

The testing of Bavaria 40S sailing boats was performed on several sailing areas depending on different wind conditions and waves. Homeport was Biagrad n/m so some monitoring was made in Pašman channel, some in Murter Sea and some in Prokljan Lake depending on wind conditions and wave heights.

In Prokljan Lake the testing on flat water was monitored, figure 4.

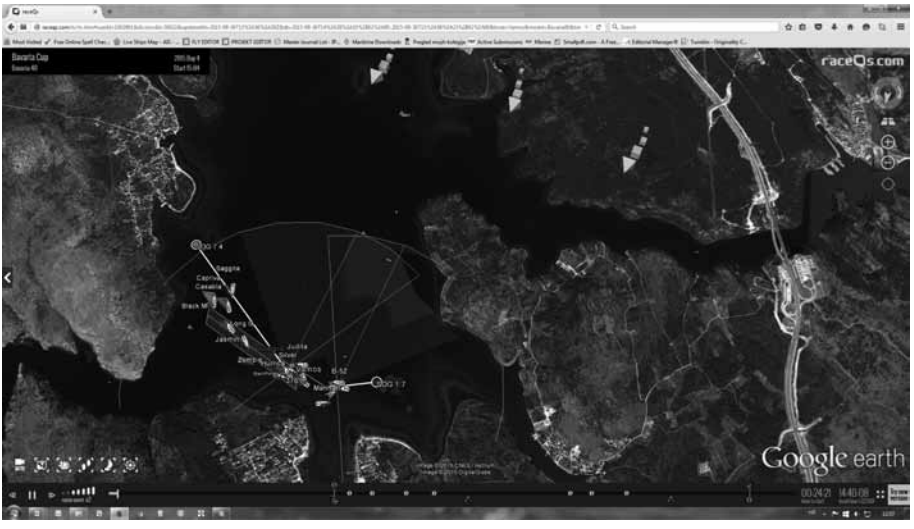

Figure 4. Monitoring in Prokljan Lake

In Pašman channel the sailing in different winds and moderate wave height (up to 1 m) was monitored, figure 5.

Figure 5. Monitoring in Pašman channel

Finally, in Murter sea the testing in the strong winds and big waves (up to 3 m) was performed and monitored, figure 6.

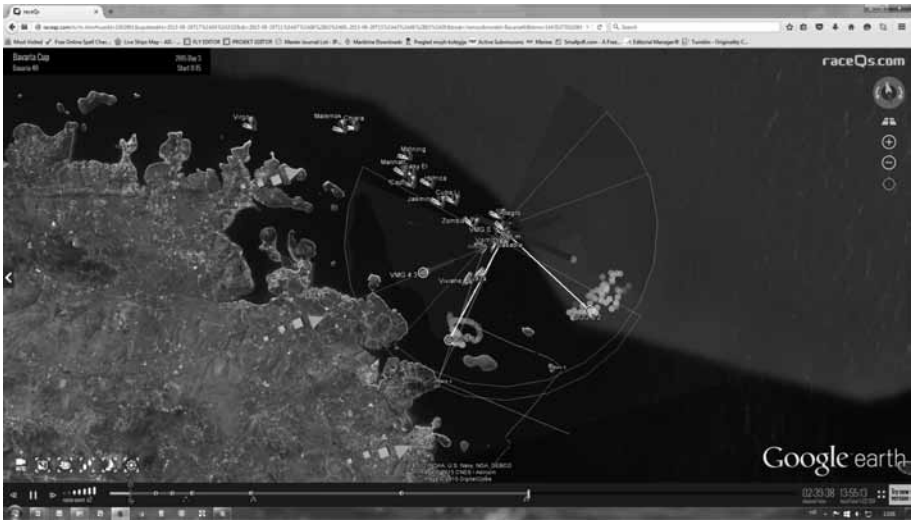

Figure 6. Monitoring in Murtet Sea

4. Results

During the testing a lot of data were collected in various wind/wave conditions, approx. 150.000 measuring points. The analysis is still in progress and only a part of processed results will be shown within this paragraph. The results of up-wind analysis in moderate wind and waves monitored in Pašman Chanel is shown in following diagram, figure 7, where the boat speed is analysed regarding jib car position.

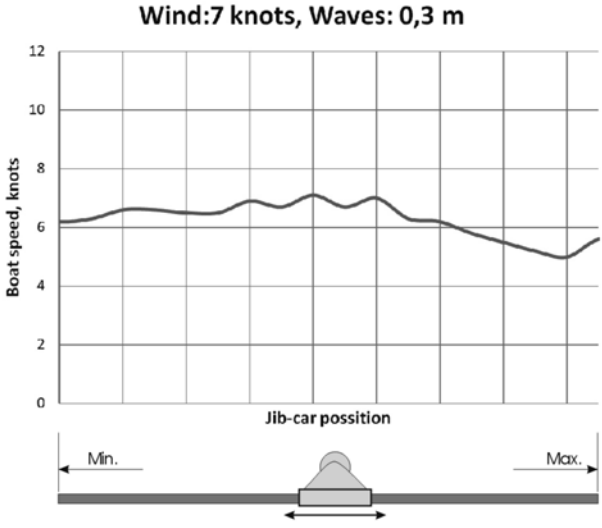

Figure 7. Up-wind boat speed vs. jib car position diagram

5. Conclusion

In this work an influence analysis of deck equipment positioning on performances in sailing was performed. For such analysis a wide sailing performance monitoring was performed by using specialised tools. A huge data base was collected and processed in order to define an optimal deck equipment position for various wind/wave conditions regarding the boat speed. Even only a part of results are processed until now the partially presented diagram is also valuable guideline for increasing performances of the selected boat type in defined wind conditions. Such diagram will be updated with 3D axis regarding the max. up-wind angle. Furthermore, the complete results will be published latter and those will be compared to the originally software defined polar diagrams.

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Analiza utjecaja razmještaja palubne opreme jedrilice na performanse kod jedrenja

Sažetak

Autori su u ovom radu izvršili analizu utjecaja razmještaja i prilagođavanja palubne opreme, a koja se nalazi u direktnoj vezi sa jedriljem, na performanse jedrilice kod jedrenja. Analiza je izvršena mjerenjima na terenu, u plovidbi pod jedrima a korištenjem specijalizirane opreme temeljene na RaceQs aplikaciji uz GPS podršku. Analiza se odnosi na dio mjerenja izvršen u uvjetima laganoga vjeta bez značajnih valova na moru, zatim pri vjetru srednje jakosti i umjereno valovitom moru i pri vjetru s olujnim udarima i valovitom moru. Prikupljanje podataka izvršeno je kroz 30 sati mjerenja i monitoringa unutar kojih se razmještaj i prilagođavanje navedene opreme kontinuirano mijenjalo s ciljem postizanja veće bezine kod različitih kuteva jedrenja. Rezultati su obrađeni i prikazani. Mjerenja su omogućena uz pomoć i suradnju s Bavaria Yachts d.o.o. Predviđen je i nastavak analize za različite uvjete vjetra i stanja mora.

Ključne riječi: Palubna oprema malih plovnih objekata, jedrilica, RaceQs, GPS podrška