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A research on Stability of Trimaran designed for Da Nang region of Vietnam

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Abstract: The authors have been working on designing a passenger trimaran according the region of Da Nang City, Viet Nam and research on its stability is one of the needed steps, although we all know trimarans have superior stability compared to a mono-hull ship of the same size. In this paper, the authors used The Dargnies and the Krilov method to determine the stability of the designed trimaran. In thecaltulation process, the AutoCad software was applied to draw and to take the values of the ship's stations areas, waterlines areas and the sinking partsvolumes.

Keywords: trimaran, passenger ship, stability

I. INTRODUCTION

Da Nang City of Vietnam is known as the most attractive seaside city in this country. In Da Nang, most of tourist enterprises use converted ships from small wooden fishing boats, leading to many dangerous accidents. These ships are very old and were designed to serve the fishing industry, so they are not suitable for tourism industry, they particularly have low transverse stability. Along with the increasing demand for waterway tourism in this area due to the attraction of big events as well as the increasing tourism position of the city, many ships are ready to carry passengers in excess of the permitted number because profits, leading to the threatened safety of passengers. A typical example is the accident of Thao Van 2 ship in June 2016. The authors have been working on designing a passenger trimaran according the region of Da Nang City and research on its stability is one of the needed steps, although we all know trimarans have superior stability compared to a mono-hull ship of the same size.

II. APPROACH AND METHODS

There is a variety of methods for calculating the statical stability moment of ships. The Dargnies and the Krilov methods are usedamong the so-called "numerical" methods based on the same fundamental principle.The generally used above-mentioned methods are developed for the usualshaped ship hull and so it is advisable to apply them only in these cases.The simplifications introduced at the development of these methods arebased on the recognition that waterlines differ slightly at two neighbouringinelinations and so do their statical moments and moments of inertia. In caseof catamarans these differences are more significant and so the usual stabilitycalculation methods result in higher error of the statical stability moment.Moreover, the amount of work of calculation, drawing and planimerisationis much higher than for a single-hull ship.The authors combined this method of calculation with the application of modern technical facilities (AutoCad 3D).

2.1 Input data of the designed trimaran

- Length overall: L_{max}=62m;
- Designed length: L_{tk}=60m;
- Breath overall: B_{max}=19.8m;
- Designed breath: B_{tk}=18m;
- Height: D=4.5m;
- Draght: d=2m;
- Volumefull coefficient: C_B=0.645;
- Waterlinefull coefficient: C_w=0.22;
- Midship section full coefficient: C_M=0.69.

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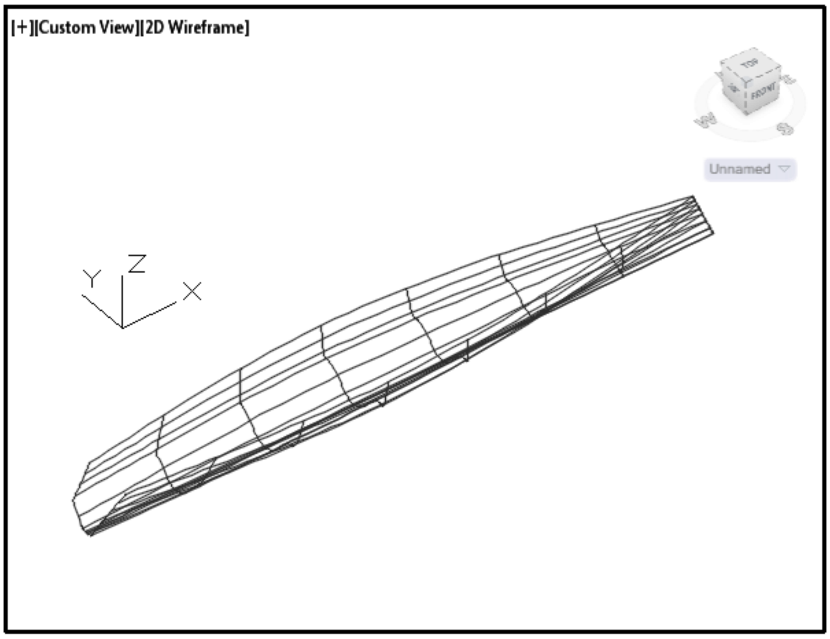

Figure 1Middle hull shape

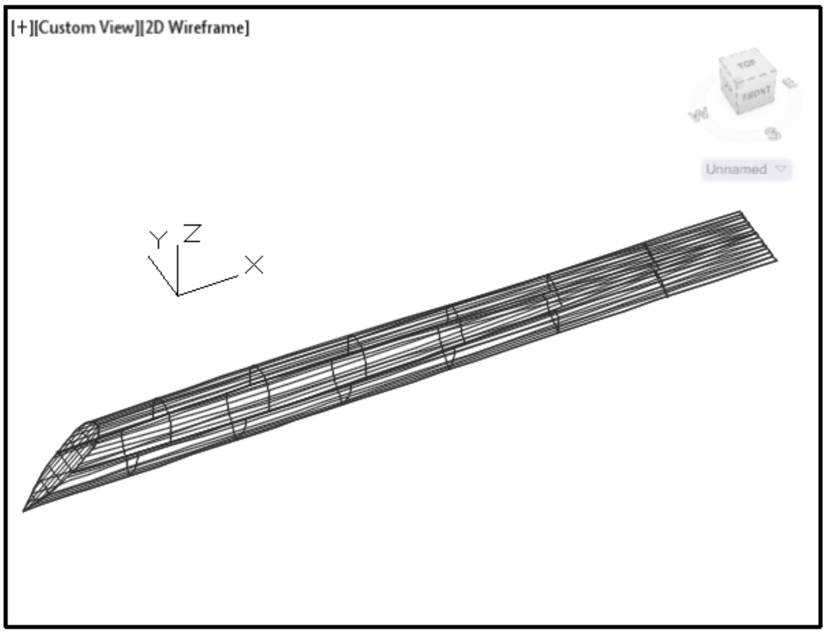

Figure 2 Side hull shape

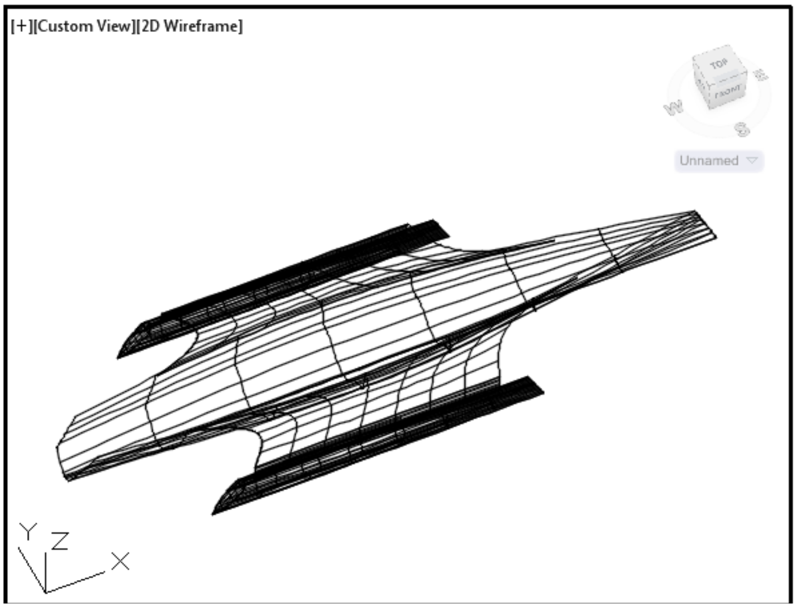

Figure 3Designed trimaran hulls shape

2.2 Drawing Chebyshev station and constructing constant volume tilt waterlines

The authors inturn to do the followings:

- Draw the Chebyshev station of the trimaran fully side to side;

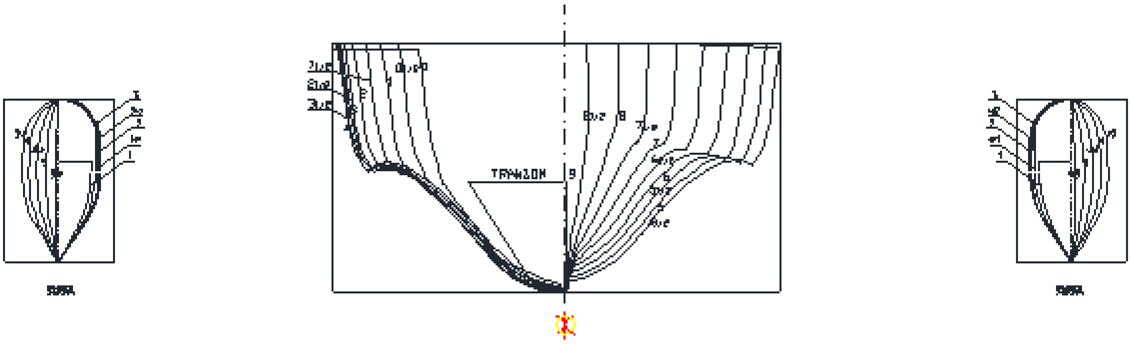

Figure 4Chebyshev stations of the designed trimaran

- Trace original waterline (when$\theta = 0^o$)WL$_0$;
- Through center O of the original waterline, draw the first auxiliary waterline under the inclination angle θ(equal to 10^o)WL$_1$
- Through the center of rotation (determined by the interpolation method), the original waterline is converted into a new waterline, where the displacementequal the displacement at the position of the ship balanced with WL$_0$.
- Find the center of rotation to bring the WL$_1$ waterline back to a horizontal state with the rotation angle of -10^o;
- Find floating center coordinates
- Find the stability lever arm (YB)
- From there determine the next waterlines WL$_1$, WL$_2$, WL$_3$, etc.
- Determine the center of rotation of WL$_2$, WL$_3$ by drawing the waterline WL$_2$'(take θ-1^o), the center of rotation is the intersection of WL$_2$ and WL$_2$'.
- Repeat the same for the next waterlines.

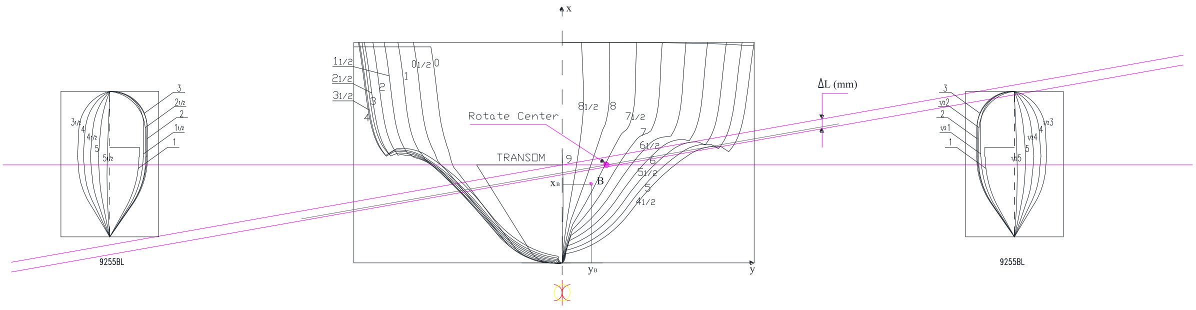

Figure 5 Determining the ship’s stability lever arms

2.3 Determiningcharacteristics of tilt waterlines at each tilt angle

The authors used AutoCad 3D software to determine the waterlines at the respective tilt angles:

- Initially, set the plane through the designed waterline, when the ship was in a balance position;
- Rotate the waterline with the corresponding tilt angle (from 10° to 90°, use Rotate3D);
- Alternately move the rotated waterline according to the direction perpendicularly to the waterline for one segment L, find 4 locations in which there are 2 locations of measured displacement (using Massprop) is greater than the designed displacementand 2 locations with the measured displacement is less than the designed displacement.
- Graph from 4 obtained values, use the interpolation method to find the waterline at each tilt angle.

III. CALCULATION RESULTS

3.1 At the tilt angle of 10°

Table 1Statical characteristics when $\theta = 10^o$

Tilt angle	10	
Δ L (m)	∇ (m^3)	Δ (T)
0	326.50	334.66
-50	314.80	322.67
-100	303.20	310.78
-150	291.80	299.10

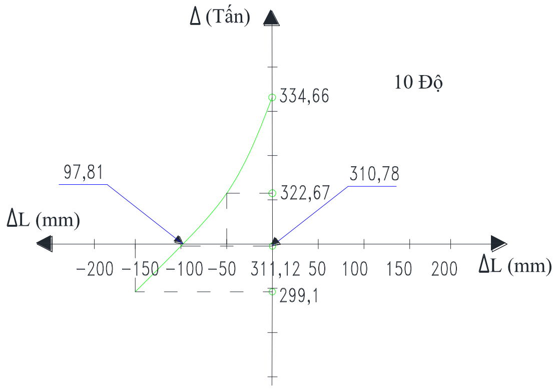

Figure 6 Interpolation graph when$\theta = 10^o$

3.3 At the tilt angle of 20°

Table 2Statical characteristics when $\theta = 20^o$

Tilt angle	20	
Δ L (m)	∇ (m^3)	Δ (T)
0	357.35	366.28
-100	333.82	342.17
-250	299.52	307.01
-300	288.38	295.59

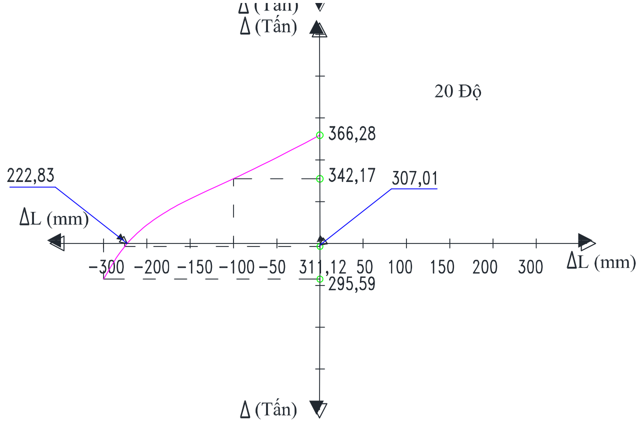

Figure 7Interpolation graphwhen $\theta = 20^o$

3.3 At the tilt angle of 30°

Table 3Statical characteristics when $\theta = 30^o$

Tilt angle	30	
Δ L (m)	∇ (m^3)	Δ (T)
-200	355.10	363.98
-400	310.63	318.40
-500	289.07	296.30
-600	268.01	274.71

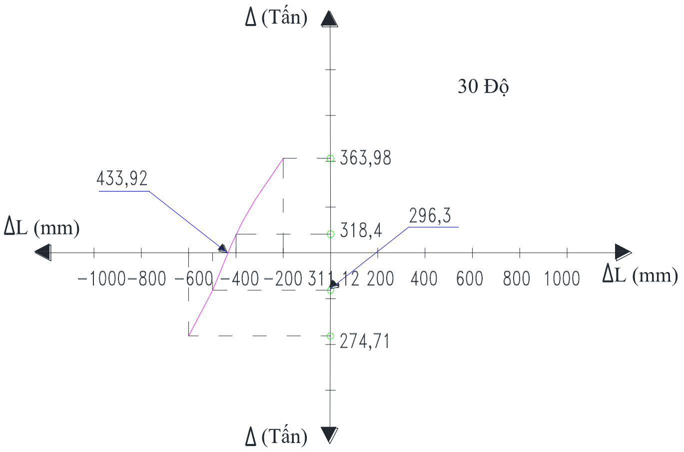

Figure 8Interpolation graphwhen $\theta = 30^o$

3.4 At the tilt angle of 40°

Table 4Statical characteristics when $\theta = 40^o$

Tilt angle	40	
Δ L (m)	∇ (m^3)	Δ (T)
-400	326.53	334.69
-500	306.89	314.56
-600	287.29	294.47
-700	192.27	197.08

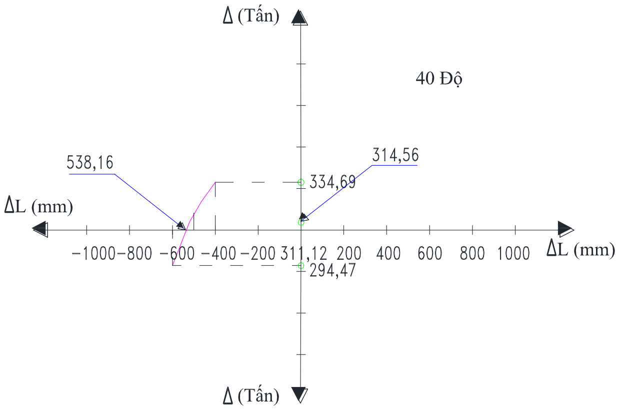

Figure 9Interpolation graphwhen $\theta = 40^o$

3.5 At the tilt angle of 50°

Table 5Statical characteristics when $\theta = 50^o$

Tilt angle	50	
Δ L (m)	∇ (m^3)	Δ (T)
-400	375.74	385.13
-500	360.23	369.24
-600	344.47	353.08
-800	313.06	320.89
-1000	281.72	288.76
-1100	266.15	272.80

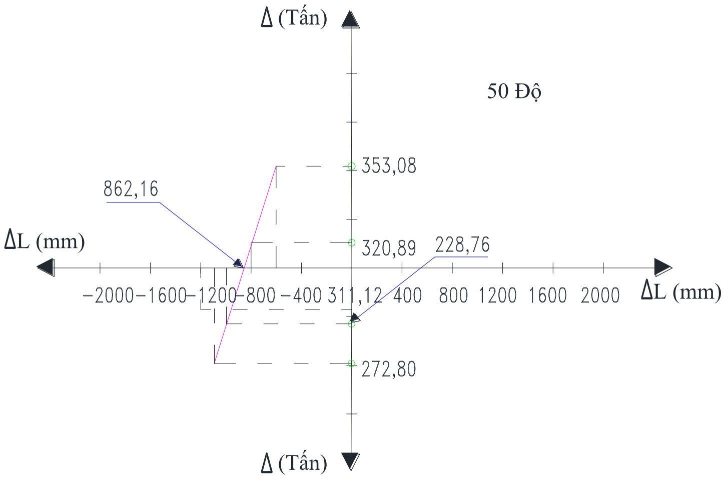

Figure 10Interpolation graphwhen $\theta = 50^o$

3.6 At the tilt angle of 60^o

Table 6Statical characteristics when $\theta = 60^o$

Tilt angle	60	
Δ L	∇	Δ
-1200	321.40	329.44
-1300	309.80	317.55
-1400	298.31	305.77
-1500	286.85	294.02

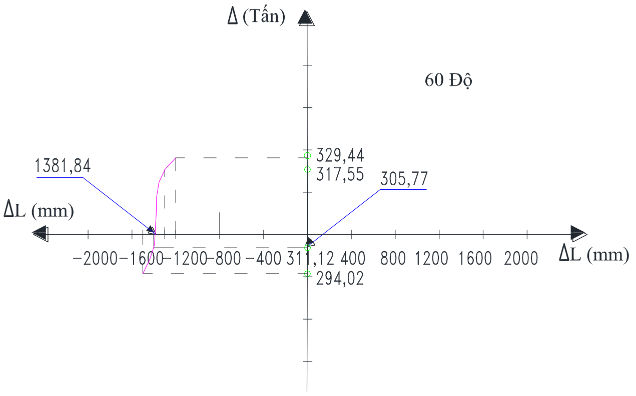

Figure 11Interpolation graph when $\theta = 60^o$

3.7 At the tilt angle of 70^o

Table 7Statical characteristics when $\theta = 70^o$

Tilt angle	70	
Δ L	∇	Δ
-1400	368.70	377.92
-1800	337.98	346.43
-2400	294.43	301.79
-2800	266.87	273.54

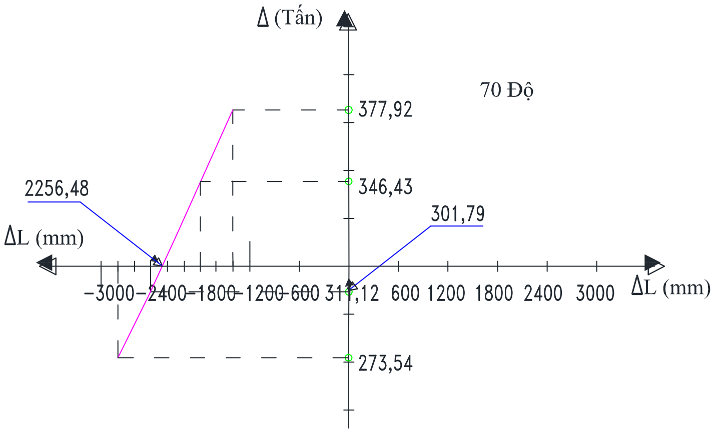

Figure 12Interpolation graph when $\theta = 70^o$

3.8 At the tilt angle of 80^o

Table 8Statical characteristics when $\theta = 80^o$

Tilt angle	10	
Δ L	∇	Δ
-2000	402.39	412.45
-3000	320.60	328.62
-4000	234.12	239.97
-5000	146.61	150.28

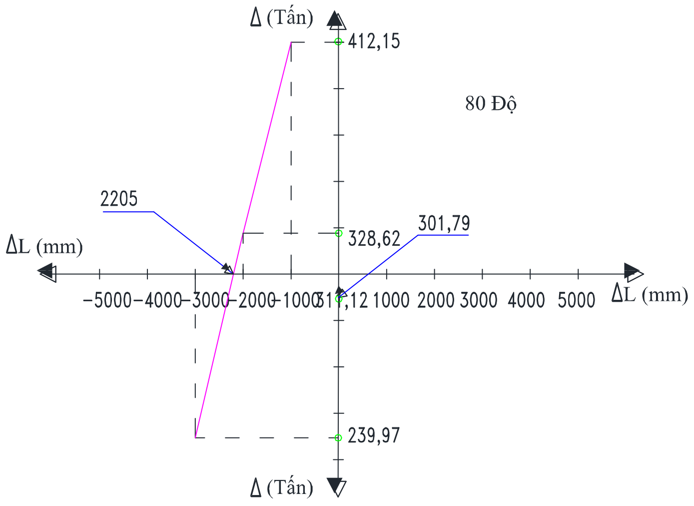

Figure 13Interpolation graph when $\theta = 80^o$

3.9Trimaran stability graph

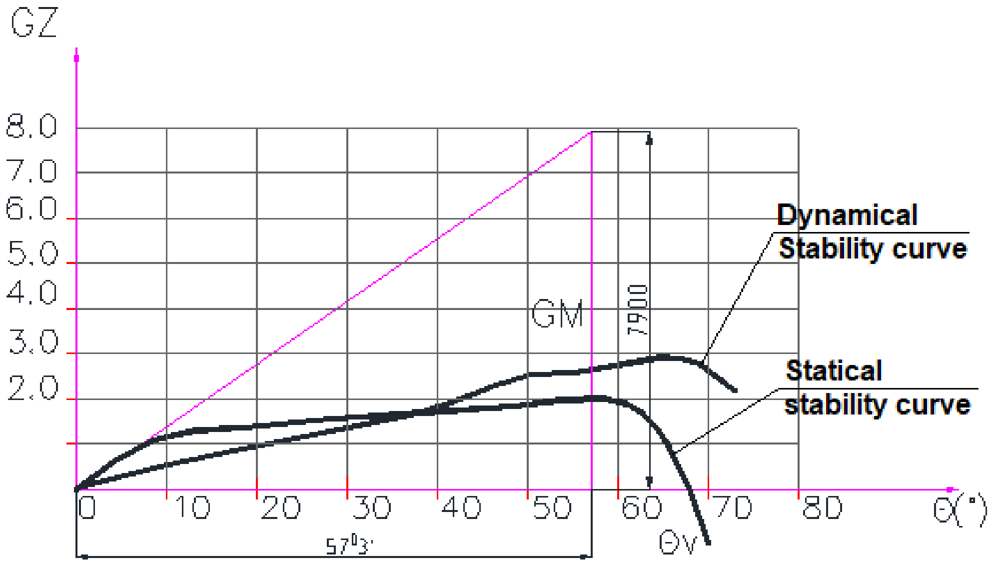

Figure 14 Stability graph of the designed trimaran

IV. RESULTS DISCUSSION

Based on the stability graph of the designed trimaran, the authors determined the value of GM and it turned out that the designed trimaran has a very high initial stability (GM = 7900mm).

The stability graph also shows that when the trimaran starts to tilt from 0^o t0 10^o, itsstability lever armincreases very fast, and after 10^o, it increases more slowly and holds the high value consistently. After 60^o, the lever arm drops very quickly to the state where the ship loses its stability.

High stability leads to a short swing cycle of the ship, which can affect the health of passengers. However, in the case the ship is designed for tourism development in Da Nang, the ship will mostly be used in calm waters, so the high stability of the designed trimaran became the most significantadvantage.

V. CONCLUSION

The method of stability calculation used in this research is a combination of traditional method and advanced technology, whichhelped to improve the calculation accuracy, at the same time, it also saves calculation time very much.

Based on the results of the calculation, the authors concluded that the designed trimaran for Da Nang region of Vietnam has very high stability. It accurately reflects the advantages of a multihull ship compared with a mono - hull one.

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