

## Comparison of the Efficiency of Williamson and Anderson Turn Manoeuvre

K. Formela, M. Gil & H. Śniegocki  
*Gdynia Maritime University, Gdynia, Poland*

**ABSTRACT:** The paper presents comparison of the 'Person over board' manoeuvres. The article was based on research conducted on a group of students of the Faculty of Navigation of Gdynia Maritime University. People involved in studies previously conducted on board training on school training ships: "Dar Młodzieży" and "Horyzont II", but did not have experience as an officers. Research was carried on the Polaris Ships Bridge Simulator, located at the faculty of Navigation, of Gdynia Maritime University.

### 1 INTRODUCTION

Safety of navigation is one of the key issues affecting the transport processes, which are used for maritime transport. Among the many threats that could undermine the proper course of the voyage, accidents related to the man falling overboard belong to a small group of events that can take place regardless of the hydro-meteorological conditions, specifics of the operated water area, traffic intensity, or other external circumstances.

Despite the tendency to constantly improve the level of safety for oversea vessels, correct response of the ship navigator, resulting in the correct implementation of the required "man overboard" manoeuvre is not always observed. The issue of POB (Person Overboard) accidents is therefore still valid, particularly that for a decade you can see steady growth of the world merchant fleet, which over the last eight years has increased by 20 357 vessels [European Maritime Safety Agency 2005-20013].

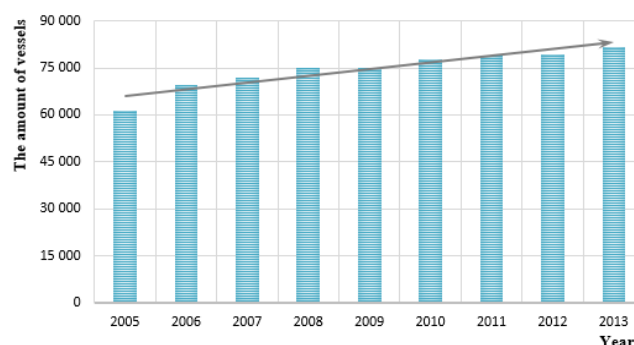


Figure 1. The number of the world merchant fleet in years 2005-2013 [European Maritime Safety Agency 2005-20013].

### 2 SIMULATION STUDIES

Because of the direct impact of the "man overboard" manoeuvre on to the rescue of human life at sea, the members of the Scientific Society "Watchers" active at the Faculty of Navigation of Gdynia Maritime

University, decided to carry out the relevant research in order to determine the effectiveness of individual manoeuvres.

The measurement part consisted, successively, of the "Williamson Turn" and the "Anderson Turn" performed by two groups of 17 students of the Navigation - Maritime Transport Faculty. Persons involved in the studies previously underwent the seagoing service onboard of training vessels - s/v "Dar Młodzieży" or "Horyzont II".

Selected for testing was navigation and manoeuvring simulator, POLARIS type, manufactured by the Norwegian company named Kongsberg. All devices operate on the basis of complex mathematical models that provide realistic reactions of an individual and his environment. In addition, they have DNV (Det Norske Veritas) certificate confirming the possibility of their use during specialized courses for crews of merchant ships).



Figure 2. Simulators used for researches [Gil, Śniegocki 2015].

### 2.1 Objectives and course of the studies

According to the assumptions, each of the tested individuals performed the exercise three times manoeuvring to the starboard. All participants were operating in the same water area and with the same hydro-meteorological conditions, which are shown in Table 1.

Table 1. Hydro-atmospheric conditions simulated in the researched water area [Gil, Śniegocki, 2015].

Depth	100 m on the entire working area
Wind speed and direction	320° - 5 kn (2°B)
Sea State	1 - Calm (rippled), 0 - 0,5 m
Current speed and direction	none
Air temperature	21°C
Visibility	8 - very good - 10 Mm
Clouds	No clouds, clear visible sky

To accomplish the task the BULK06L model was selected - it is a fully loaded, 215-meter bulk carrier with a displacement of more than 60 000 tonnes [Kongsberg Maritime, 2015]. In order to shorten the exercise, it was beginning with a course 000° with the settings of an engine order telegraph (E.O.T.) "FULL SPEED AHEAD" and the maximum speed of the ship - 15.9 knots.

In the designed task a man was initially held at a distance of 380 m from the bow of the vessel so that the vessel, when floating past the man's position, was positioned parallel to it. The applied solution made it possible to simulate a situation in which the victim has just fallen overboard. Information about the initiation of the POB alarm was sent to steering units with radio communications at a time when the survivor has passed the right traverse of the ship. In practice, this meant the circumstances in which the distance from the initial position of the vessel to the POB position was about 500 m. Simulations were constructed in such a way so that the man placed in the water was not affected by the drift of wind, making his position constant during the entire manoeuvre.

Since none of the tested persons had previous experience with the applied model of the ship, the first attempt was carried out in accordance with the description of the manoeuvre contained in the "International aviation and maritime search and rescue guide" (IAMSAR).

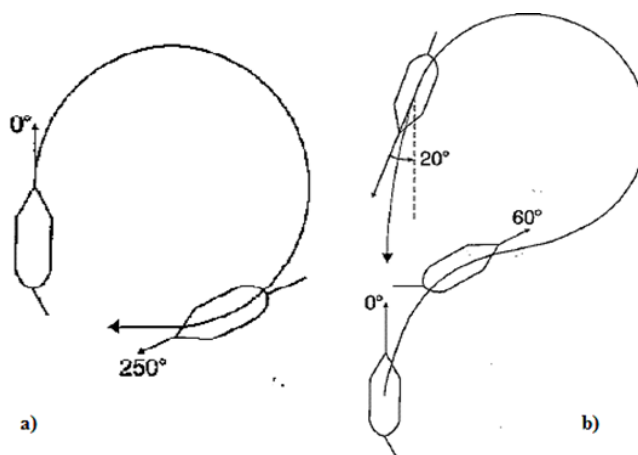


Figure 3. „Anderson Turn” (a) and „Williamson Turn” (b) as per IAMSAR [International Maritime Organization, 2008].

If as shown in Figure 3, the guide containing the guidelines of the International Maritime Organisation (IMO) suggests the following sequence of action in case of an immediate manoeuvre - the "Anderson Turn" [International Maritime Organization, 2008]:

- Move the rudder on the side from which a man fell;
- After reaching a change in the course by the value of 250°, set the rudder in the "zero" position;

In the case of the "Turn Williamson" manoeuvre IAMSAR recommends the following procedure [International Maritime Organization, 2008]:

- Move the rudder on the side from which a man fell;
- After reaching a change in the course by the value of 60°, set the rudder on the opposite side;
- When the course reaches the value lower by 20° than the counter course as compared to the initial settings of the vessel, set the rudder in the "zero" position.

Both at the first and the second manoeuvre, the initiation and intensity of the process of stopping of the vessel was carried out at the discretion of an individual performing the exercise. During the

research further tests were carried out on the basis of previous experiences of participants. At the time of the exercises execution, those involved in the exercise modified the course of the manoeuvre - in accordance with their convictions based on the analysis of the chart showing the route of the first test. Each approach was considered as completed when the navigated vessel had reached a speed of less than two knots. That criterion was adopted due to the recognition that such speed level was sufficient for safe deployment of a rescue boat.

During the exercise, at the position of an instructor (a technical operator of the simulator) they recorded the following real-time dynamic parameters of the vessel, in two second intervals:

- reference number of a measurement;
- duration of the exercise [hh: mm: ss];
- course [°];
- direction of the water route [°];
- speed [knots];
- speed change [knots / min];
- latitude;
- longitude;
- heading (HDG) [°];
- actual position of the rudder [°];
- defined position of the rudder blade [°];
- rate of turn [° / min].

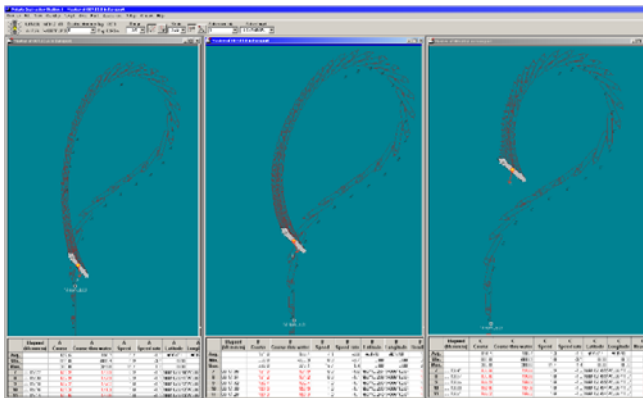


Figure 4. Recorded tracks and data. Preview on the instructor station.

### 3 DEVELOPMENT OF THE COLLECTED DATA

After collecting all the measurements, it was necessary to extract from them those parameters that ultimately were to be used to investigate the effectiveness of POB manoeuvres. The described attributes included: execution time of the "Williamson Turn" and the "Anderson Turn" along with the stopping of the vessel ( $t_m$ ), as well as latitude and longitude ( $\varphi, \lambda$ ) at the end of the manoeuvre ( $V_k < 2$  knots).

#### 3.1 Coordinates transformation

For the implementation of the charts being the projection of obtained final positions of the ship on the plane, it was necessary to transform the geographical coordinates to Cartesian X, Y. For this purpose they applied the relationship between

rectangular coordinates and their counterparts on the ellipsoid of revolution (spheroid). In order to increase the accuracy of the obtained calculations they used the Gauss-Krüger coordinate system reproduction for the axial meridian 006°, based on the following relationships [Specht et al. 2013]:

$$x = k \cdot R \cdot \left[ \frac{S(B)}{R} + \frac{(\Delta L)^2}{2} \cdot \sin B \cdot \cos B + \frac{(\Delta L)^4}{24} \cdot \sin B \cdot \cos^3(B) \cdot (5 - t^2 + 9 \cdot \eta^2 + 4 \cdot \eta^4) \cdot \frac{(\Delta L)^6}{720} \cdot \sin(B) \cdot \cos^5(B) \cdot (61 - 58 \cdot t^2 + t^4 + 270 \cdot \eta^2 - 330 \cdot \eta^2 \cdot t^2 + 445 \cdot \eta^4) \right]$$

$$y = \left[ \Delta L \cdot \cos(B) + \frac{(\Delta L)^3}{6} \cdot \cos^3(B) \cdot (1 - t^2 + \eta^2 + \eta^4) \cdot \frac{(\Delta L)^5}{120} \cdot \cos^5(B) \cdot (5 - 18 \cdot t^2 + t^4 + 14 \cdot \eta^2 - 58 \cdot \eta^2 \cdot t^2 + 13 \cdot \eta) \right]$$

After obtaining the rectangular coordinates they calculated the average position of all measurements and the distance separating the ship from the position of man at the end of the manoeuvre. For this purpose they applied the properties of a loxodromic triangle - and similar calculations were performed for the data obtained.

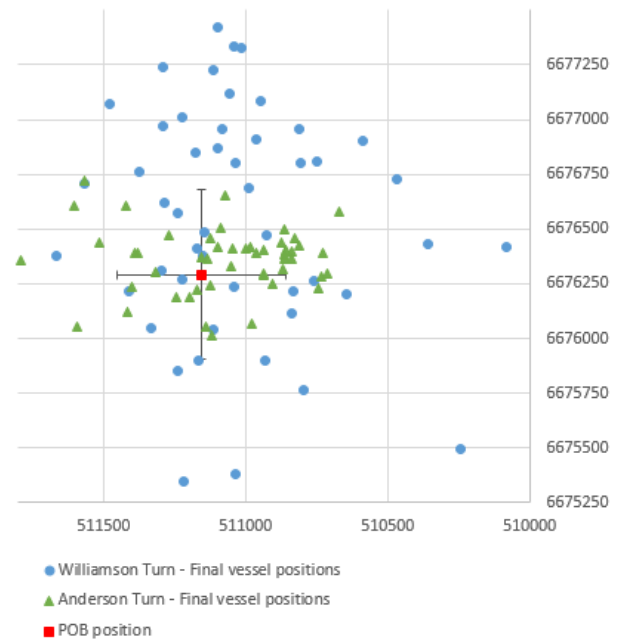


Figure 5. Spread of received final positions with respect to the POB position for the Williamson Turn and the Anderson Turn.

#### 3.2 Breakdown of the results with respect to implemented trials

Following the alignment of geographical coordinates they analysed the results as divided into three attempts. They sorted and counted the average values of the distance (from the POB position) and the duration for individual approaches. The summary of results is presented in Table 2.

Table 2. Average values of manoeuvres time and distances to a man for individual tests.

Attempt	Williamson Turn		Anderson Turn	
	$D_{POB}$ [m]	$t_m$ [min]	$D_{POB}$ [m]	$t_m$ [min]
1.	608.84	18.12	344.09	11.43
2.	542.45	15.56	267.65	10.79
3.	606.50	14.73	263.45	11.24

According to the above a table can be seen a gradual shortening of the duration of manoeuvre of each successive trial - especially in the case of the "Williamson Turn." This fact results from a practical familiarization of a tested individual with the handling/manoeuvring characteristics of the vessel and the modification of the generalized scheme of action based on the analysis of the earlier manoeuvre.

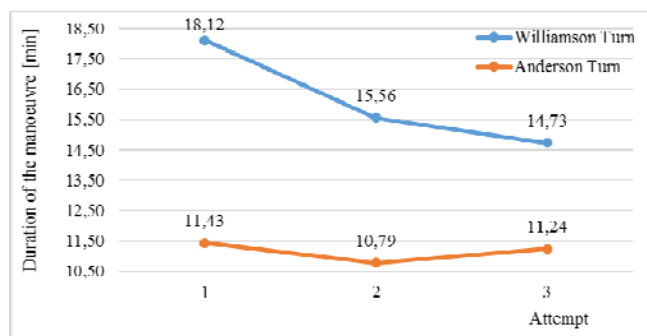


Figure 6. Graph with average duration of the manoeuvres in particular attempts

Based on the results concerning the course of the "Williamson Turn" it can be concluded that the smallest distances from the average position and the position of man were obtained at the second attempt. In the case of the "Anderson Turn" the approach results in both the 2nd and 3rd trial were very close, but definitely different from the results obtained in the 1st approach. This may result from the analyses of the previous manoeuvre carried out by students, getting practically acquainted with the properties of a marine vessel and the implementation of amendments to the generalized scheme of manoeuvre proposed in the IAMSAR.

The values obtained at the third time (especially in the case of the "Williamson Turn") being smaller than at the first approach, while higher than at the second, may result from probably too much confidence emerging in the helmsman who noticed a significant improvement as compared to the manoeuvre implemented as the first one. This may result in a reduction of concentration, being at ease, and ultimately getting worse results.

Visible differences between the results obtained with both manoeuvres are slightly different - in the case of the "270° turn" data are similar. This is probably due to the simplicity of executing of the said manoeuvre and the limited ability to modify the approach itself. In the case of the "Williamson Turn," which is assumed to be a longer manoeuvre, the differences in the results obtained in subsequent attempts are much more apparent.

#### 4 CALCULATION OF EFFICIENCY OF POB MANEUVERS

In order to test the effectiveness of the manoeuvre, it was necessary to allow the indicator to quickly determine whether a manoeuvre had been performed successfully. While attempting to define a model describing the indicator, the following requirements were accepted:

- zero-dimensionality;
- obtained values  $\leq 1$ ;
- taking into account the time of a manoeuvre ( $t_m$ );
- taking into account the distance of the ship from a POB position ( $D_{POB}$ );
- being shot manoeuvre "man overboard";
- grasping the essence of the POB manoeuvre performance.

Given the above assumptions, it was decided to translate all the values obtained to one form. Because  $t_m$  is not the total time that separates the commencement of a "POB" type manoeuvre by a ship until rescuing a man, it was necessary to determine the total duration of the manoeuvre ( $t_c$ ). For this reason all its components were summed:

$$t_c = t_m + t_l + t_r$$

where

$t_m$  = duration of "POB manoeuvre" [min],

$t_l$  = duration of rescue boat launching [min],

$t_r$  = time required to pass  $D_{POB}$  distance by the rescue boat [min].

$$t_r = 60 \cdot \frac{D_{POB}}{V_r}$$

where

$V_r$  = rescue boat speed [kn].

Due to the assumption regarding the occurrence of the worst conditions - in accordance with the charts presented in the IAMSAR - they assumed the average smallest amount of time a man can survive in the water with the lowest test temperature, namely 60 minutes.

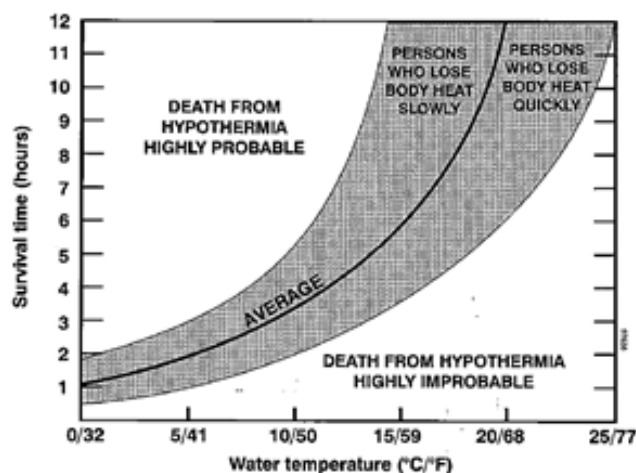


Figure 7. Effects of the hypothermia in different water temperatures [11].



According to the accepted model the G indicator was calculated for all measurements made. The most effective manoeuvre made by the student using the "Anderson Turn" reached a value of 0.263; while the least efficient 0.341. For the "Williamson Turn" the best value obtained was 0.380; and the worst 0.571.

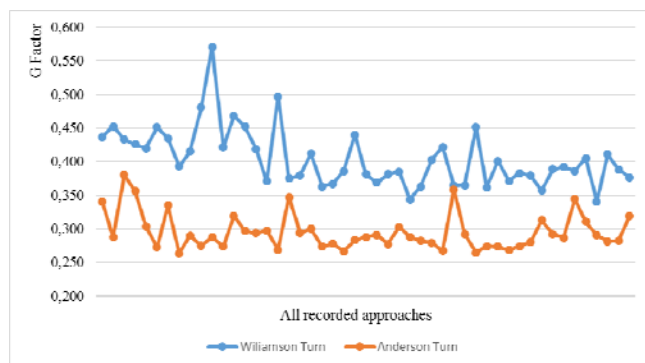


Figure 8. G Factor for Williamson and Anderson Turn.

Both from the above graph and the values obtained it follows that in the case of an immediate rescue action, when the moment of a man falling overboard was observed by a person leading the vessel or the crew on the bridge, the most effective method of approach to a man from among those described above is the "Anderson Turn." It is worth noting that even the most effective test performed while applying the "Williamson Turn" was only slightly better than the least effective approach using the "single turn" method.

As the obtained results show, the biggest impact on the effectiveness of the manoeuvre has the time of its execution, and in a lesser extent - the distance between the ship and the man.

An example of such measurement can manoeuvre in which with "Turn Williamson" achieved  $D_{POB} = 517.9$  m (which is a value close to the average). G totalled 0.344; which is the second of the best values obtained. This was possible due to the favourable overall time manoeuvre  $t_c = 20.63$  min.

An example of such measurement can be a manoeuvre in which an application of the "Williamson Turn" helped to achieve  $D_{POB} = 517.9$  m (which is a value close to the average). G totalled 0.344; which is the second of the best values obtained. This was possible due to the favourable overall time of the manoeuvre  $t_c = 20.63$  min.

## 5 CONCLUSIONS

Based on the carried out survey it was found that the greatest impact on the effectiveness of the implemented manoeuvre is that of the acquired experience. From the presented charts it follows that

with each new attempt, the duration of the manoeuvre was reduced. The variable that most significantly affects the presented efficiency ratio of a manoeuvre is  $t_m$ , so one can conclude that every next POB manoeuvre performed by the same person was more effective.

The research shows that, especially in good hydro-atmospheric conditions, the distance between a man and a stopped vessel is less important than the duration of the whole manoeuvre. This is because it is faster and more precise to reach the position of a man with a rescue boat rather than to approach him by a ship. It was not tested how the aforementioned situation affected the effectiveness of the manoeuvre in circumstances in which, due to the occurrence of adverse weather conditions, there is a need to shield the man and the rescue boat from the sea waves.

The presented results also demonstrated the superiority of the "Anderson Turn" over the "Williamson Turn" during the implementation of aforementioned manoeuvres in the immediate rescue operation. This is due to the simplicity of the "270° turn," which translates directly into its duration and also efficiency. The values obtained indicate the saving of time of up to 5 minutes when the "Anderson Turn" is selected as a variant of the approach to the man who fell overboard, with respect to the mean values of all the times obtained by both methods. In a situation when the drowning man is overboard, this value is a huge gain for the benefit of all involved in the action.

## BIBLIOGRAPHY

- Gil M. & Śniegocki H., „Efektywność manewru «Pętla Williamsona»”, *Logistyka* 4/2015, ss. 3381-3392, 2015.
- European Maritime Safety Agency, „The world merchant fleet in 2005: Statistics from Equasis”, European Maritime Safety Agency, 2005-2013.
- International Maritime Organization i International Civil Aviation Organization, *IAMSAR Manual: International Aeronautical and Maritime Search and Rescue Manual*. London/Montreal: IMO/ICAO, 2008.
- International Maritime Organization, „Resolution MSC.218(82): Adoption of amendments to the International Life-Saving Appliance (LSA) Code”. International Maritime Organization, 2006.
- International Maritime Organization, *LIFE-SAVING APPLIANCES: 2003 Edition, Combined edition*. London: International Maritime Organization, 2003.
- International Maritime Organization, Red., *SOLAS: Consolidated Edition, 2004*. London: International Maritime Organization, 2004.
- Kongsberg Maritime, „Description of Ship Model: BULK06L: Version 14”. Kongsberg Maritime, 2013.
- Specht C., Szot T., & Specht M., „Badanie dokładności personalnych odbiorników GPS w pomiarach dynamicznych”, *Technika Transportu Szynowego*, nr 10, ss. 2547-2555, 2013.