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# Manoeuvrability
# Evaluation and Documentation of HSMV

## 1. PURPOSE OF PROCEDURE

These procedures address the manoeuvrability of High Speed Marine Vehicles (HSMV), especially those not governed by the IMO Interim Standards for ship manoeuvrability. The class is comprised of a large variety of hull shapes, such as monohull, which may be semi-planing or planing, catamaran, trimaran, hydrofoil, and surface-effect and hovercraft. Evaluation of the manoeuvrability will be carried out using appropriate existing procedures (see ITTC Quality Manual, 2012: Captive Model Test Procedure, Free Running Model Test Procedure, Manoeuvring Trial Procedure, Validation of Manoeuvring Simulation Models). In general, these procedures are applicable to HSMVs, but this procedure describes only the additional items needed for manoeuvrability of HSMV.

Usually, the common element of HSMV is the high Froude number. The ABS (2008) rule formula is:

$$V\,(\text{knots}) \geq 2.36\, L(\text{ft})^{1/2}$$

corresponding to a Froude number of 0.7.

Besides the definition based on Froude number, other criteria exist, based on the absolute speed value and as it relates to the environment of operation:

- ratio of harbour manoeuvring speed to service speed;
- ratio of service speed to service speed of other ships;
- rating on a scale incorporating human controllability, or traffic density.

In accordance with the definition of high speed by the 21st ITTC (1996) High Speed Marine Vehicles Committee, based on (but slightly modified) the IMO (2008) Code of Safety of High-Speed Craft, the following criteria must both be satisfied:

$$Fn_{\nabla} = \frac{V}{\sqrt{g \cdot \nabla^{1/3}}} > 1.18$$

$$V\,(\text{kn}) \geq 25\ \text{kn}$$

The critical displacement is $\nabla_C = 1764\ \text{m}^3$; hence smaller vessels will meet the first condition travelling at less than 25 knots, while large vessels may not meet it even if they are travelling more than 25 knots.

All vessels above 100 meters in length are subject to the IMO Interim Standards for ship manoeuvrability; hence, the manoeuvring performance of these vessels will be assessed through these standards. However, many HSMV are below 100 meters in length and do not qualify. Also, most HSMV are passenger ships, for which safety may be an issue when subjecting them to the standard manoeuvring tests, especially at high speed.

## 2. DESCRIPTION OF PROCEDURE

Evaluation of HSMV manoeuvring can be performed by different methods:

- free running model tests

- simulation model based on captive model tests
- full scale tests
- CFD

For some of these methods, appropriate procedures exist (see ITTC Quality Manual, 2012: Captive Model Test Procedure, Free Running Model Test Procedure, Manoeuvring Trial Procedure, Validation of Manoeuvring Simulation Models). In general, these procedures are applicable to HSMVs, but some special devices and/or test techniques might be further required to consider the following specific aspects.

- At high speed, HSMV may exhibit strong dynamic effects during manoeuvring, e.g. yaw-roll coupling.
- Manoeuvring properties vary greatly over the speed range of HSMVs (low-speed, take-off, cruising; transient phases of dynamic lift vehicles).
- High speed induces a higher frequency of encounter with obstacles in a cluttered environment, requiring special attention to emergency manoeuvres, including crash stops, turning and collision avoidance.
- Dynamic properties of sensors, actuators, and the control system play a significant role in HSMV manoeuvring because the physical response of the vessel is very fast.
- Course keeping ability in a seaway must be assessed, with particular emphasis on broaching in following and stern quartering seas.
- HSMV often reduce speed:

  a. in cluttered seaways or in channels and harbours to reduce the risk of collision;
  b. in rough seas to avoid excessive dynamic loads;
  c. to reduce wake wash effects when near shore or in enclosed areas. Hence these ships must satisfy some manoeuvring requirements at reduced speed as well.

- Depending on operational requirements, the HSMV may also require manoeuvring performance at very low and zero speeds. The effects of wind at low speed should be checked.
- Foil-assisted boat stability in calm and rough seas, i.e. motion control systems.
- The running attitude of a planing craft affects the manoeuvring performance greatly (Ikeda et al.(2000). So, in the case that captive model test are carried out, heave and pitch should be free for a planing craft with a system which would not impart any vertical forces to the model during towing (Kim et al.(2012)).
- When PMM test is done for a planing hull, the motion frequency should be carefully selected. If the motion frequency coincides with the rolling natural frequency, the large roll motion could induce violent heave and pitch motion; analogous to parametric rolling but now for heave and pitch. Katayama et al. (2000)
- Since the vertical motions of HSMV affects the hydrodynamic forces on the horizontal plane highly, a 6-DOF mathematical model is recommended for accurate maneuvering simulation of HSMV. This requires that the HSMV has to be kept under various occurring heel angles, pitch angles, and vertical positions: a set of PMM or rotating arm tests should be repeated at multiple heel angles, pitch angles and drafts. From these tests, the heel-yaw coupling, pitch-yaw coupling and heave-yaw coupling can be derived.

As a means of reference for assessing their manoeuvring qualities, HSMV can be asked to satisfy the same IMO manoeuvring requirements in calm water as for conventional ships, even if they have length less than 100 meters. Additional requirements, such as safety during fast evasive manoeuvres may be required in this case, particularly for smaller craft and those with a surface-piercing bow. For instance, smaller craft have horizontal acceleration limits during evasive manoeuvres that require a limit on engine power (Ueno et al, 1999). Bowles (2012) described possible manoeuvring criteria for high-speed monohulls.

The choice of sea state for manoeuvring tests depends on the type and certification of ship (some vessels are not certified for all weather). Normal operating sea state, where the ship can operate at all headings and speeds, and worst intended conditions with reduced speed must be considered.

Progress in the linear and non-linear hydrodynamic analysis of fast ships (Lin & Yue, 1990; Faltinsen & Zhao, 1991; Kring et al, 1997) allows the simulation of the wave induced motions of ships. However, a combined hydrodynamic and manoeuvring analysis without experimentally determined coefficients is still not feasible except in the preliminary phase. For accurate manoeuvring assessment, using captive model tests and/or free sailing models are recommended.

## 3. PARAMETERS

The required parameters are the same as for conventional hull ships. Model testing poses the same requirements as for conventional ships, and should be augmented to include testing for broaching.

## 4. DOCUMENTATION

The same documentation is required as for conventional hull ships.

## 5. REFERENCES

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