DRAFT *GUIDELINES FOR UNIFORM OPERATING LIMITATIONS OF HIGH-SPEED CRAFT*

1 INTRODUCTION

1.1 An explicit element of the *Code of Safety for High-Speed Craft, 2000* (2000 HSC Code – "the Code") is that unrestricted operation is not suitable for high-speed craft and that operating limitations are necessary. In this regard, attention is drawn to clauses 1.2, 1.3.4 and 1.4.61 of the Code

1.2 These guidelines have been prepared to assist in the uniform implementation of the Code as amended in 2007, in particular paragraph 1.9.7 and Annex 12, and to provide information on the rationale underpinning such operating limitations.

1.3 It should be noted that the factors listed in Annex 12 of the Code are prefaced by the words "as a minimum" and may, where appropriate, be supplemented by other factors where the flag and/or port State Administrations are of the view that those additional factors are applicable to the satisfactory operations of the craft under the Permit to Operate.

Drafting Note:

1. ***It has been suggested that there is no need for much of the content of Annex 12 if the pre-existing provisions of the Code, including Annex 9, are applied in their entirety. The Group should closely examine this assertion and make recommendations to the Sub-Committee as appropriate.***
   UK considers Annex 12 should stay as is.
   China agree
   RINA: Factually this suggestion is correct. However it is precisely because the Code was not being applied consistently that RINA proposed and DE and MSC adopted the new Annex 12. It is outside the remit of the ISCG to tell DE that Annex 12 is unnecessary, particularly when they have previously and deliberately agreed with the insertion of the new Annex 12, which has now passed into the amended Code. RINA supports Annex 12 in its current form.
   U.S.: Changing the HSC Code is out of terms of ref. Further, Annex 12 is guidance to ensure uniform application of ops limits, which is not readily apparent in its current form. RECOMMEND leaving Annex 9 and 12 as is.
2. ***On the other hand, it has also been suggested that Annex 9 trials would become unnecessary for craft that are fitted with instrumentation in accordance with the drafting note to para 8.4 of these draft Guidelines.***
   UK doesn't agree that Annex 9 trials might be redundant
   China agree
   RINA : While the suggestion may have merit, it is again outside the remit of the Correspondence Group to amend Annex 9 of the Code. We could however, if this were to be agreed, insert text into the Guidelines suggesting that

Administrations might consider whether the permanent fitting of such instrumentation might be deemed to provide equivalent safety to some of the provisions of Annex 9. That is, achieve the aim by "equivalence" rather than by trying to change the Code, which we cannot do.
U.S.:- Instrumentation which provides acceleration info (along with significant wave height vs speed tables, weather info, etc) is provided to assist Masters in their decision-making. Requiring such equipment, or reliance on it may require a change in the HSC Code, which is outside the terms of ref. In addition, this may also require Administrations to provide additional oversight for such equipment.
Australia: Disagree with the US that the use of instrumentation is outside the terms of reference of the Corro Group.
Co-ordinator: The amendment of the HSC Code is outside our terms of reference, so Annexes 9 and 12 are not proposed to be amended. However, covering-off both of the drafting notes, the Guidelines can provide guidance on arrangements that are accepted as being at least equivalent to those of the Code.

1.4 Matters determining the operating limitations set out in the craft's Permit to Operate, as outlined in these guidelines, may relate to one or more of the following three sectors:

.1 those affecting the safety of the craft as a whole;

.2 those specifically affecting the safety of the passengers and crew as individuals; and

.3 those affecting the safety of persons outside the craft.

1.5 The operating limitations established under these guidelines should relate to the craft's normal operations. For example, if an automatic ride control system is normally used in conditions approaching the *worst operating conditions*, then that system should be assumed operational for the establishment of the operating limitations but should also be included in the FMEA analysis specified in the Code.

1.6 Any operating limitations resulting from consideration of all the relevant factors outlined in the following sections of these guidelines should define the permitted operational envelope for the craft. Those limitations should be described in clear but succinct terms on the Permit to Operate and the Craft Operating Manual and clearly communicated to the craft's operating personnel.

2 MAXIMUM DISTANCE FROM REFUGE

2.1 Clause 1.3.4 gives time limits for passenger craft (4 hours) and cargo craft (8 hours) for the passage to a *place of refuge* (defined in 1.4.48 of Code) when proceeding at 90% of *maximum speed* (as defined in 1.4.38 of Code). This is to allow the craft to operate solely in areas where the necessary shore-based support is available and to safely retire to shelter in the event of changes in the weather and sea state.

2.2 This limitation is generally set by the referenced provisions of the Code, but should be clearly stated in the craft's documentation and shown on the permit to operate unless covered indirectly (eg. by coordinates of boundaries of the operational area).

2.3 The maximum distance from base port or place of refuge should be established in accordance with clause 18.1.4 of the Code taking account of the relevant limits specified in 1.3.4 of the Code.

3 AVAILABLE RESCUE AND OPERATIONAL SUPPORT RESOURCES

3.1 In some cases the operating limitations are functions of the resources available on the route, rather than the craft's limitations. Specifically, the Code is predicated on adequate communications facilities, weather forecasts and maintenance facilities being available within the area of craft operation. Taken in conjunction with the requirement for proximity to place of refuge, the weather forecast requirement is intended to facilitate timely decision-making with regard to seeking refuge.

3.2 In setting the operating limitations, the Administrations should consider whether the wave height corresponding to the w*orst intended conditions* should be such as to permit the craft to complete its passage without relying on a drastic reduction in speed, thus increasing the exposure of the passengers and crew to progressively more severe conditions. Such consideration relates to the craft being considered its own best survival craft in deteriorating conditions.

3.3 Clause 1.2.7 of the Code states: *"in the intended area of operation, suitable rescue facilities will be readily available."* Further, clause 1.4.12.1 states that a category A high-speed craft is one *"operating on a route where it has been demonstrated to the satisfaction of the flag and port States that there is a high probability that in the event of an evacuation at any point of the route all passengers and crew can be rescued safely within the least of:*

- *the time to prevent persons in survival craft from exposure causing hypothermia in the worst intended conditions,*

- *the time appropriate with respect to environmental conditions and geographical features of the route, or*

- *4 hours"*

3.4 The words "a high probability" in this text should be taken to mean that the probability of an evacuation not being successful is "remote" as defined in Annex 3 of the Code.

3.5 Although the Code gives no guidance on what constitutes "suitable rescue facilities", the Permit to Operate should only be issued where the flag and relevant coastal State Administrations are satisfied that appropriate measures have been implemented and an appropriate assessment made that demonstrates to their satisfaction that the Code's requirements are met across the operational area in accordance with 18.2.2.4 of the Code. For this purpose the Administrations may require the application for the Permit to Operate to be accompanied by an analysis of shipping traffic and other resources likely to be available in the operating area in the event that the craft evacuates and rescue is required. Assessment of suitable rescue facilities through trial evacuation or rescue exercise may be highly beneficial in identifying gaps and weaknesses and in improving overall performance in preparation for an actual rescue, but should not normally be required.

3.6 Appropriate consideration should be given to the seasonal availability of resources. For example, presence of ice due to seasonal variation may render a specified place of refuge unusable due to navigational safety considerations.

Drafting Note:

The text of section 3 has been updated to reflect the outcome of COMSAR 12, by removal of square brackets and revision of final sentence of para 3.5.

UK supports changes

China agree

RINA: Accepted.

U.S. - Agree with proposed change

Co-ordinator: Cross-reference inserted in 3.5 to emphasise existing Code requirement

4 WIND FORCE, MINIMUM AIR TEMPERATURE, VISIBILITY & DEPTH OF WATER

4.1 Clause 1.4.61, in defining the *Worst Intended Conditions*, makes specific reference to the following parameters, which should therefore appear on the Permit to Operate, when appropriate:

.1 significant wave height (refer section 5 of these guidelines)

.2 wind force (refer Chapter 2, 1.1.4 of Annex 6, 1.3 and 2.2 of Annex 7 and 1.1 and 2.1.4.3 of Annex 8. For example, in worst intended conditions the maximum wind pressure should not exceed that used in the craft's stability calculations, nor should it create aerodynamic lift beyond that associated with the craft's normal operating attitude)

.3 minimum air temperature (reference for example brittle fracture properties of materials, susceptibility to icing and resulting effect on stability, etc)

.4 visibility (eg. conditions of impaired vision and night navigation may necessitate improved navigation equipment or night vision equipment)

.5 minimum safe water depth (eg. safe navigation, bottom scouring, adverse effects on seabed flora & fauna, wash waves (see 7.2 below)).

4.2 The matters outlined in the preceding paragraph are intended to only comprise an illustrative and non-exhaustive list. They may be supplemented by the Administrations to include, for example, the effect of sea ice on the craft's structure and machinery and its ability to navigate safely and reach a place of refuge.

5 SEA STATE LIMITATIONS - SIGNIFICANT WAVE HEIGHT

5.1 General

5.1.1 The *worst intended* sea *conditions* are usually set in terms of a *significant wave height* value as defined in 1.4.54 of the Code. These guidelines are prepared on the assumption that this parameter is used but the underlying principles are still applicable if another parameter is used. In applying the guidelines it should be noted that craft motions are dependent upon wave period as well as significant wave height.

5.1.2 For operational purposes, significant waveheight is most reliably measured either by satellite or by a system providing real-time monitoring of the height between the sea surface and a point on the craft in conjunction with gyroscopic measurement of accelerations at that point. Alternatively, significant waveheight readings could be provided by transmitting-type wave measurement buoys located along the route. In the absence of such systems, visual observations of significant wave height will be necessary, for which the guidance provided at Appendix A may be used.

5.1.3 Sea state limitations applicable to a craft may vary according to the craft's course relative to waves, but for each course should not be greater than the lowest sea state derived from taking account of the factors listed in the remainder of this section.

5.2 Damage Stability

5.2.1 In clause 2.6.11 of the Code, the required minimum residual freeboard to downflooding is a function of the significant wave height corresponding to the *Worst Intended Conditions.*

5.3 Structural Safety

5.3.1 It is clearly vital to the structural integrity of a high-speed craft that the craft is not operated outside the limitations to which the structure has been designed.

5.3.2 In this regard, and bearing in mind the equivalence of safety standards of craft covered by the Code with those of SOLAS in accordance with SOLAS Chapter X, it should be noted that regulation II-1/3-1 requires that:

> *………ships shall be designed, constructed and maintained in compliance with the structural, mechanical and electrical requirements of a classification society which is recognized by the Administration in accordance with the provisions of regulation XI-1/1, or with applicable national standards of the Administration which provide an equivalent level of safety.*

5.3.3 Some classification society rules base their structural loadings on a limiting vertical acceleration at the longitudinal centre of gravity. In order to avoid exceeding this structural limitation, the societies may issue the craft with a diagram developed from this assumption, which relates the maximum permitted speed of the craft to the prevailing significant wave height. Refer to 8.2 of these guidelines in relation to presentation of the resulting operating limitations, which may be determined by other factors in accordance with 1.6.

5.3.4 Sometimes speed reduction in waves may be involuntary, due to increased resistance. But deliberate speed reduction is generally necessary in order to stay within safe limits in high sea states.

Drafting Note:

Amendment proposed to clarify that this is not a "requirement" as such but standard operating procedure to secure the craft's safety.

5.4 Dynamic Stability

5.4.1 Safe operation of most high-speed craft is significantly affected by the sea state. Safe seakeeping limitations may be as a result of some of the examples listed in clauses 2.1.5 and 17.5.4.1 of the Code, including most particularly: propensity to deck diving or broaching; incidence of hull or wet-deck slamming; plough-in, yawing and turning. Refer to the guidance information in Appendix B in relation to operations in following and quartering seas.

5.4.2 Implied but not explicit these limitations should also include excessively violent motions affecting the passengers and crew (see also sub-section 5.6 of these guidelines).

5.4.3 Clause 18.1.3.2 of the 2000 HSC Code requires that the Administration be satisfied that the operating conditions on the intended route are within the capabilities of the craft. This should be verified during the trials conducted in accordance with Annex 9 and invoked by clause 17.2.1 of the Code.

5.4.4 Administrations should note that clause 3.1.2 of Annex 9 of the Code explicitly states that "*worst intended conditions, referred to in 1.4.57 of this Code, are those in which it shall be possible to maintain safe cruise without exceptional piloting skill. However, operations at all headings relative to the wind and sea may not be possible.*" This provision should be taken into account when setting operating limitations in relation to dynamic stability.

5.5 Safe Deployment of Evacuation Systems & Survival Craft

5.5.1 The Code places great emphasis on the ability to evacuate a high-speed craft quickly and safely, the maximum evacuation time being linked (in 4.8.1) to the Structural Fire Protection time. To this end, 8.6.5 requires that: "*Survival craft shall be capable of being launched and then boarded ... in all operational conditions and also in all conditions of flooding ....*"

5.5.2 "All operational conditions" includes all intact loading conditions without reference to environmental conditions. ~~It is understood/considered(RINA) that~~ "All conditions of flooding" was included to take account of~~, by considering~~ damage conditions defined in Chapter 2 of the Code~~, of situations similar to the incident in which the catamaran ferry *St Malo* was holed in 1995~~. [1]

Drafting Note:

The reference to the St Malo ***incident may have served its purpose within the Group and the second sentence might therefore be amended by deletion of ', by considering' and the remaining text after 'Chapter 2 of the Code'.***

UK prefers to remove St Malo reference

China: Tend to agree to the mentioned amendment, and also hope the detail explanation to the word "situations similar to the St Malo incident" could be included in this guidance in order to avoid different understanding.

RINA: Agreed, but should read: "... take account of the damage conditions ..."

U.S. - Agree with proposed removal OR to assist in the readability of this document, RECOMMEND citing the specific circumstances of the ST MALO case vice just providing a reference.

Co-ordinator: Reference proposed to be converted to footnote, as shown, reflecting the majority view.

5.5.3 Where the craft is to be evacuated by MES complying with the requirements of the Code, the Code assumes that the environmental conditions required for the

[1] Reference is made to the evacuation of *St Malo* in 1995 following a damage incident.

heavy weather sea trial (in accordance with 12.6 of Res. MSC.81(70) as amended) provide an assurance of operability of the MES in heavy weather. Experience has shown that heavy weather sea trials in more severe conditions than those specified for type approval of MES involve physical danger for the personnel involved without significant assurance of increased safety.

Drafting Note:

It is suggested that the square brackets around the last sentence could be deleted.
UK happy for [ ] to be deleted
China's comments: agree
RINA Comment: Agreed.
U.S. - Agreed, remove the last sentence
Co-ordinator: Square brackets deleted, reflecting majority view.

5.5.4 Where the craft is to be evacuated directly into survival craft in accordance with 8.7.5 of the Code without the use of MES, the Administrations may require evacuation trials on the craft or an identical sister high-speed craft to be conducted in weather and sea conditions up to the *worst intended conditions* specified in the Permit to Operate, in order to assure itself that such evacuation can be carried out safely in such conditions.

5.6 Safe Handling Limitations

5.6.1 The Code makes reference to three Safety Levels (see Table 1 in Annex 3) and prescribes the acceptable probability that each Safety Level may occur. Level 1 is expected to have a probability of occurrence of greater than 10^{-5}, i.e. Frequent or Reasonably Probable. Table 1 in Annex 3 reveals that for Safety Level 1 (Minor Effect) only prescribes that horizontal accelerations should not exceed 0.2g.

5.6.2 In applying these standards it should be noted that clause 4.3.1 of the Code advises that superimposed vertical accelerations exceeding 1.0g at the longitudinal centre of gravity should be avoided "unless special precautions are taken with respect to passenger safety". For vertical accelerations exceeding 1.0g then hazards for safe seating of passengers and crew will ensue.

5.6.3 Similarly, Table 1 in Annex of the 2000 HSC Code stipulates acceptable maximum horizontal accelerations for severe and extreme operating conditions.

5.6.4 Table 2 in Annex 3 of the 2000 HSC Code makes it clear that Safety Level 2 relates to conditions when emergency procedures are required and passengers may be injured, and Level 3 to conditions when there is a large reduction in safety margins, and serious injury to a small number of occupants may occur.

5.6.5 The upper limit of Level 2 corresponds to the *Worst Intended Conditions* - see 3.3.2 of Annex 9 of the Code. Passengers must be seated before the onset of Level 2 in accordance with Code provisions 4.2.4 and Annex 9 para 3.3.2.

5.6.6 Many forms of high-speed craft may have safe handling limitations as suggested in 17.5.4.1 of the Code, for example:

.1 Amphibious hovercraft may have to avoid certain speed and drift angle combinations in order that plough-in or skirt tuck-under and possible capsizing do not occur.

.2 Many forms of high-speed craft may have to avoid excessive bow-down trim in order to preserve safe manoeuvring behaviour, such as avoidance of bow-diving or broaching - see clause 17.2.1 of the Code.

.3 Guidance in this safe handling may be obtained from Appendix B and MSC.1/Circ.1228 as appropriate bearing in mind that the latter document is largely addressed to conventional ships.

5.6.7 Chapter 17 of the Code requires full-scale testing to determine operating limitations and procedures for operation of the craft within limitations. Annex 9 defines the test procedures needed to develop these operational limits. In particular Section 3 of Annex 9 and Table 1 of Annex 3, define the horizontal and vertical acceleration levels which must not be exceeded to ensure passenger safety. Under normal operation conditions, craft must not exceed Safety Level 1 (0.2g in horizontal plane) at maximum operating speed as per 3.3 of Annex 9 of the Code. In worst intended conditions, craft cannot exceed Safety Level 2 (0.35g in horizontal plane). Vertical acceleration measurements are also required by Annex 9, and these limits are driven by structural limitations for which craft must not exceed the limiting vertical acceleration at the longitudinal centre of gravity as per paragraph 4.3.1 of the Code and 5.3.3 of these guidelines. The above limits, trial results, and the Significant Wave Height to Speed Table inform the process of defining operational limits. It should be noted that paragraph 17.4 of the Code requires the trials conducted under Annex 9 to include verification of the effects of failure(s) identified as being critical.

Drafting Note:

Insertion made to clarify that there is no ban on exceeding Safety Level 1 but that passengers must be seated when operating in Safety Level 2.

5.6.8 Although clause 17.1 of the Code makes provision for use of data from model tests where appropriate, ~~wherever practicable~~ use of such data should be confirmed by suitable trials of the craft or an identical craft. Model tests should be used to evaluate safe limits in situations that would be hazardous to investigate during sea trials. For these purposes, model tests should be taken to include mathematical modeling as well as testing of a physical model.

5.6.9 The references to vertical accelerations in clause 4.3.1 and Table 1 of Annex 3 of the Code should be interpreted as referring to the mean of the 1/100th highest accelerations (not RMS), which should be measured using the criteria of footnote 1 of Table 1 of Annex 3.

6 Trials demonstrating performance in relation to operating limitations

6.1 The *worst intended conditions* of wind and sea may not be available for the conduct of the verification trials required by Chapter 17 of the Code, in which case some extrapolation of satisfactory trial results may be necessary. Any extrapolation should take account of the non-linear nature of seakeeping behaviour and of variation in wave period (frequency) and height (amplitude). In such cases, the *worst intended conditions* specified on the craft's Permit to Operate should not exceed 130% of the significant waveheight in which the verification trials were conducted. Extrapolation of wave period should be conducted separately from waveheight. Extrapolation is not applicable to trials conducted under 5.5 of these guidelines. Where satisfactory trials have been completed on a craft, then those trials are not required on subsequent identical sister craft provided the operational envelope of waveheight and wave period is not significantly changed. Any extrapolation based on trial results of another closely similar design of similar size (length and breadth both within 5% of that of the craft in question), must be verified through trials of the craft in question.

Drafting Notes:

1. ***The delegation of the United Kingdom at DE 51 expressed concerns about extrapolation under this paragraph. The Group was instructed to take such comments into account.***
   UK: Proposes to remove 6.1 entirely until such time as a procedure for passing/failing is established and the extrapolation includes structure as well as seakeeping, or alternatively limit extrapolation to 110%.
   Co-ordinator: There is no support for deletion of the paragraph. To the contrary, various delegations have supported its retention and provision being made for extrapolation.
2. ***Extrapolation may be an important factor affecting shipbuilding contracts, particularly if waves of the specified significant wave height and period are not readily available in the vicinity of either the shipyard or the operational area. Shipbuilding contracts generally require the craft to be fully certificated before entering service.***
   RINA: Understood.
   U.S. Noted.
   Australia: Perhaps some members of the Corro Group have limited exposure to oceanography. A requirement for trials to be undertaken in different wave heights and within 70% of the design operating limitation "with no variation in wave period" is practically impossible and cannot be achieved. It will be technically embarrassing to put this into an IMO Code when this cannot be done. This is why we have been proposing the use of computational analysis to supplement trials – not to replace trials.
   Co-ordinator: Text amended in an attempt to accommodate the various comments.
3. ***If insufficient provision is made for extrapolation, the craft may have to cease scheduled operations in sea conditions in which it can operate safely or may have to be subjected to trials in worse conditions than those for which it is to be***

certificated. It should be the Group's aim to at least resolve the square brackets – in Australia's view the maximum permissible extrapolation should be no less than 130% but it could be safely set substantially higher if extrapolation uses the most advanced available computational methods.
UK: If this paragraph is retained, extrapolation should be limited to 110%.
RINA: The extrapolation limit should be NOT MORE THAN 130%.
U.S. - We support the 130% extrapolation limit. While we are not opposed to extrapolation beyond this limit, we would need further information and validation of models before supporting this proposal. Since the group should only be commenting on the [bracketed text] this issue may not be within the terms for this group - Any comments from the coordinator?
Australia: The 130% is already a reduction from the 150% recently inserted in 3.2 of Annex 9.
Co-ordinator: The 130% would seem to strike a relatively conservative approach to what is required to meet the needs of industry and the even higher capabilities of modern computational methods.

4. *Extrapolation may be based upon full scale measurements for closely similar craft of slightly smaller size.*
RINA: Agreed
U.S. Agree, this is implied in 17.1
Australia: Agreed
Co-ordinator: Proposed amended text reflect this
5. *The Group should give consideration to whether the above text with regard to wave period adequately covers the subject, and if necessary develop improved text*
UK suggests extrapolation on amplitude only (same frequency)
RINA: Agreed.
Australia: It is impractical to require and conduct trials that exactly reflect the limiting operational wave period, especially when computational methods are available to satisfactorily take account of such variations.
Co-ordinator: Separation of extrapolations of wave height and period would seem to be an appropriate approach, given that both extrapolations are feasible.
6. *No provision is made for determination of operating limits by seakeeping computation rather than by full-scale trials, so when computational methods are used trials still need to be conducted to verify the computed results.*
RINA: This is as it should be.
U.S. - Per 17.1, seakeeping computations should inform the conduct of and validate full-scale sea trials. No provisions should allow computations without validation.
Australia: Agreed
7. *Some builders regard it to be impractical or impossible to develop, especially through trials alone, a matrix of wave height, wave period, wind effects, current speed/direction and craft trim/speed to which craft response can be related.*
China: If reliable and consistent measures of extrapolation couldn't be provided in the Guidelines, China would like to suggest that model tests as indicated in para.3.2 of Annex 9 of the Code can be used for demonstrating performance in relation to operating limitations.
RINA: We support the use of computations to extend the completeness of

seakeeping information, provided that it is firmly and adequately confirmed by sea trials.
***U.S.* - As noted by the coordinator, the group should only consider the text in square brackets. As stated in our previous comments, the U.S is satisfied with the 130% extrapolation limit.**
***Australia* – Disagree with UK proposal to delete this para in its entirety. After all, extrapolation of 150% was inserted for in para 3.2 of Annex 9 through MSC.222(82).**
***Co-ordinator:* There should be no need to conduct trials in relation to structure, as proposed by UK, as such trials are not required in other IMO instruments. Proposed text has been amended as shown to reflect what is taken to be a strong majority view, including deletion of [ ] around "130%".**

6.2 In order that extrapolation of wave height may be conducted in a consistent manner, a minimum wave period should be associated with each significant waveheight used to establish the *worst intended conditions*.

7 [Navigational matters

7.1 Casualties to high-speed craft have illustrated that there are number of navigational circumstances that need to be taken into account when establishing the operating limitations under the Permit to Operate. These include:

.1 Adequacy of fixed navigation aids on the route;
.2 Night vision with regard to unlit obstacles; and
.3 Other restricted visibility.

7.2 Administrations should note that clause 3.1.2 of Annex 9 of the Code explicitly states that "*worst intended conditions, referred to in 1.4.57 of this Code, are those in which it shall be possible to maintain safe cruise without exceptional piloting skill. However, operations at all headings relative to the wind and sea may not be possible.*" This provision can be taken into account by Administrations when setting operating limitations in relation to the craft's course-keeping and ability to follow alternative courses in worsening weather and sea conditions.

7.3 Minimum safe water depth may relate to local environmental regulations or hazards to other craft, persons and property in the operational area in addition to navigational safety. For example, the Administrations may require investigation of wash waves generated by the craft that are hazardous to nearby small craft and persons on the shoreline[2], investigation of environmental hazards due to erosion, and any restrictions on craft speed on the specific route in relation to water depth[3] in order to avoid these hazards should be stipulated in the Permit to Operate.

[2] Refer for guidance in Appendix C "Risk assessment in relation to wake wash waves"
[3] This is based on depth Froude Number but is also dependent on the depth profile adjacent to the shore.

7.4 Where a route is considered to be especially vulnerable to grounding or stranding, Administrations may require a risk assessment of these hazards, considering the applicability of for example:

.1 minimum safety margins around particular hazards

.2 reduced speed in critical sections of a passage

.3 requiring two navigators in the operating compartment during critical sections of the route.]

Drafting Note:
The above section has been kept in square brackets pending comments by NAV 54.

8 Display of Operating Limitations

8.1 All operating limitations shown on the Permit to Operate, irrespective of whether they relate for example to geographical boundaries or limits of wind, weather and sea conditions, should be presented in a manner that provides simple and clear direction to the craft's personnel and should be immediately available to the operator in the operating compartment. Supplementary and more detailed information may be provided in the Craft Operating Manual or Route Operational Manual, as appropriate.

Drafting Note:
The amendments shown in relation to the DE 51/13 text are proposed in order to emphasise the fact that the operating limitations shown on the Permit to Operate need only be a summary of more detailed limitations listed in the Route Operational Manual. It should be noted that the Permit to Operate is valid for five years whereas the Route Operating Manual is a living document.
UK agrees with changes
RINA: Geographical limitations should be in the Route Operational Manual, but wind and sea limits, because they must be based on trials that will probably not be repeated when the craft changes routes, should be given in the Craft Operating Manual.
China: Agree with the amending to the para 8.1.
U.S. – Agree
Australia – The number of factors taken into account on setting the operational limitations, which may for example extend to machinery matters outside these Guidelines, may necessitate direct reference to the Manuals rather than working directly from a plaque.
Co-ordinator: Proposed text amended to cover all contingencies, broadly as outlined by RINA but taking account of all comments.

8.2 The displayed information should generally not extend beyond the limits of permitted operations. Where additional information is provided, for example, to place the boundaries of the operating area in geographic context, the presentation should be such as to clearly indicate that operations outside those boundaries is not permitted. Similarly, any displayed information on speed-waveheight limitations should show only the net operating limitations determined according to all factors these guidelines and not simply those relating to, for example, structure.

8.3 Limitations with regard to significant waveheight, if varied according to heading, may be presented in a number of forms, including:

.1 polar diagram showing safely attainable speed versus wave height and relative heading, since the safe speed in head seas will often be less than that attainable on other headings (see Figure 1 below); or

.2 graph(s) having different lines for heading angles from head through to stern at intervals of not more than 15 degrees (see Figure 2 below).

8.4 Instruments may be installed to guide the craft's personnel in maintaining safe operating conditions by direct onboard monitoring of vertical and lateral accelerations and/or measurement of waveheight. ~~However, the installation of~~ Where such instruments are permanently installed, the installation should:

- be calibrated and verified by or on behalf of the flag Administration as providing accurate and reliable information to operating personnel for the safe operation of the craft in accordance with 4.2.4;
- meet the requirements of 17.1 for the conduct of verification trials;
- be supplemented by sea state limitations that are to be adhered to in the event of failure of the instrumentation; and
- trials required by Annex 9 should be limited to those necessary under above sub-paragraph 1 for verification of the instrumentation system.

Instrumentation that has not been verified under these requirements is only for the guidance of operating personnel and its installation cannot be in lieu of the imposition of operating limitations with regard to sea state and the defining of such limitations on the Permit to Operate~~, even if the instrumentation system is that used for the conduct of trials in accordance with 17.1 of the Code~~.

Drafting Note:

This paragraph ignores the fact that instrumentation is required to be fitted to verify that the prescribed accelerations are not exceeded during the Annex 9 trials, but relies upon the outcomes of those trials to establish limiting sea states for the craft's operation. In fact, such instrumentation should be fitted to enable the Master to act in accordance with 4.2.4 if the Code. It would therefore be logical for the paragraph to end after the first sentence, so that the instrumentation can be left on board and used by the Master as a direct measurement of the craft's operational safety rather than be subordinate to seastate limits derived from similar measurements during Annex 9 trials. In fact, a case exists for requiring Annex 9 trials only on craft that are not permanently fitted with such instrumentation.

UK does not support removal of second sentence

__RINA__: If the intent is to remove wind and wave limitations entirely provided that relevant instrumentation is permanently fitted, then we do not agree. The Code **REQUIRES** *the insertion of these limitations – see Annex 2, item 12, and clause 1.4.61 of the Code. Changing the Code is not in our remit.*
__China__: Agree
__U.S.__ - Agree that 8.4 should end after the first sentence. See also U.S. comments on Section 1, drafting note 2. The U.S. is not opposed to any proposal which would allow for instrumentation to provide direct, real-time operational safety data. However, this proposal must be further developed before we will support. Items such as instrument accuracy, reliability & functionality must be defined.
__Australia__ – It should be noted that the above text provides for a standard of instrumentation that exceeds requirements for conduct of Annex 9 trials (for which there are no instrumentation and calibration standards). For information, the accelerations are typically measured using what are called Motion Response Units. Typical units are sealed type, with a guaranteed performance, such as the various MRUs made by Kongsberg. There are of course other manufacturers. It is used by some builders as the motion sensor for the ride control, so is fitted on board anyway.
__Co-ordinator__: Paragraph re-drafted to take account of all comments as far as practicable

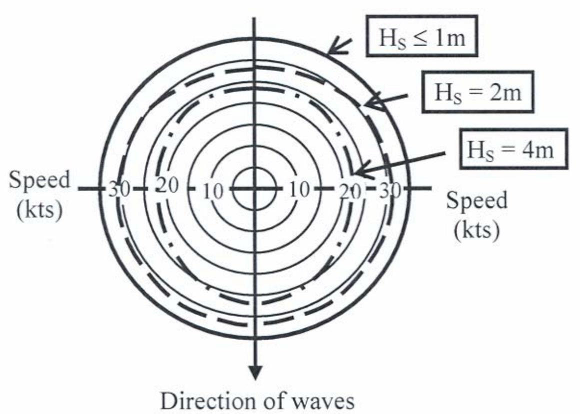

Figure 1

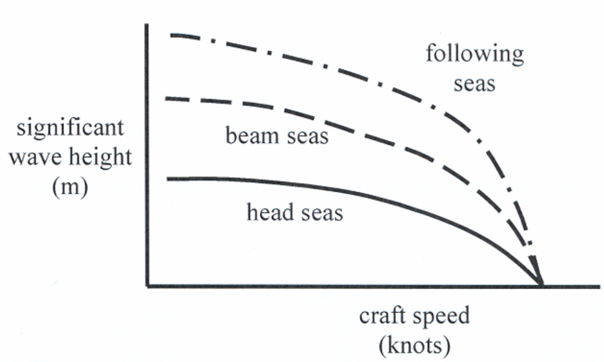

Figure 2

APPENDIX A

Visual estimation of significant wave-height

(reproduced from Meteorological Office (UK), *The Marine Observers Handbook*, Her Majesty's Stationery Office, London, 1969)

Drafting Note:

The delegation of Greece at DE 51, supported by the Bahamas, expressed some concerns about this Appendix in relation to the variability of wave behaviour in different operational areas. The Group was instructed to take such comments into account. Any proposals to improve or replace the proposed content of the Appendix would be welcomed.

UK no proposals

China: Appendix A is useful information

RINA: The existing text is acceptable as guidance, it is not mandatory. It could perhaps be condensed somewhat.

A typical record of wave traces is shown in Figure A1 below.

The record is, in general, complex and shows immediately all the difficulties inherent in eye observation. For example, are all the waves to be considered on an equal footing or are only the big waves to be counted? Since the wave characteristics vary so much, what average values shall be taken? It is obvious that if comparable results are to be obtained the observer must follow a definite procedure. The flat and badly formed waves ("A" in Fig. A1) between the wave groups cannot be observed accurately by eye and different observers would undoubtedly get different results if an attempt were made to include them in the record. The method to be adopted, therefore, is to observe only the well-formed waves in the centre of the wave groups. The observation of waves entails the measurement or estimation of the following characteristics:

Direction Period Height

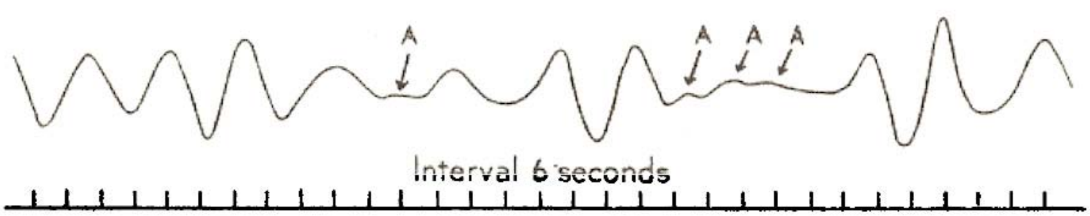

FIG. A1. Wave form of the sea-surface

Reliable average values of period and height can only be obtained by observing at least twenty waves. Of course these cannot be consecutive; a few must be selected from each succeeding wave group until the required number has been obtained. Only measurements or quite good estimates are required. Rough guesses have little value and should not be recorded. It will often be found that there are waves coming from more than one direction. For example, there may be a sea caused by the wind then blowing and a swell caused by a wind that has either passed over or is blowing in a distant area. Or there may be two swells (i.e.. cross swells) caused by winds blowing from different directions in distant areas. In such cases the observer should distinguish between sea and swell, and report them separately, giving two groups for swell when appropriate. The direction, height and period of the sea wave may be quite different from that of the swell wave. It will, however, often happen-particularly with winds of Beaufort force 8 and above-that the sea and swell waves are both coming from the same direction. In that case it is virtually impossible to differentiate between sea and swell and the best answer is to look upon the combined wave as being a sea wave and log it accordingly.

Observing waves from a moving ship. Care must be taken to ensure that the observations, especially those of period, are not influenced by the waves generated by the motion of the ship.

(i) DIRECTION FROM WHICH THE WAVES COME. This is easily obtained either by sighting directly across the wave front or by sighting along the crests of the waves and remembering that the required direction differs from this by 90 degrees. Direction is always recorded true, not magnetic.

(ii) PERIOD[4]. For measurements of period a stopwatch is desirable. If this is not available an ordinary watch with a seconds hand may be used or, alternatively, a practised observer may count seconds. The observer selects a distinctive patch of foam or a small object floating on the water at some distance from the ship, and notes the time at which it is on the crest of each successive wave. The procedure is repeated for the larger waves of each successive group until at least twenty observations are available. The period is then taken as the average time for a complete oscillation from crest to crest. In a fast ship it will be found that the "patch of foam" method will rarely last for more than one complete oscillation and that many waves have to be observed separately. With practice, suitable waves can easily be picked out and the timing from crest to crest becomes quite simple. When it is desired to use an object (an empty beer can is usually conspicuous against the sea and will remain afloat long enough to serve its purpose) it should be thrown as far forward as possible. Another method available to the observer with a stopwatch is to observe two or more consecutive "central" waves of a wave group while the watch is running continuously, then to stop the watch until the central waves of the next wave group appear, the watch being then restarted. This procedure is repeated until at least twenty complete oscillations have been observed. The period is then obtained by dividing the total time by the number of oscillations. It is important to note that the periods between times of crests passing a point on the ship are not the ones required.

(iii) HEIGHT. Although wave-recorders are fitted to a few research ships, there is at present no method of measuring the height of waves suitable for general use on merchant

[4] **Note (additional to original text):** There are several different definitions of wave period, such as modal period, zero up-crossing period etc.. The visual observation of wave period does not necessarily represent the necessary wave periods required for numerical processing, and corrections should be made as appropriate.

ships, but a practised observer can make useful estimates. The procedure to be adopted depends on the length of the waves relative to the length of the ship. If the length of the waves is short in comparison with the ship's length, i.e., if the ship spans two or more wave crests, the height should be estimated from the appearance of the waves at or on the side of the ship, at times when the pitching and rolling of the ship is least. For the best result the observer should take up a position as low down the ship as possible, preferably amidships where the effect of pitching is least, and on the side of the ship towards which the waves are coming.

This method fails when the length of the waves exceeds the length of the ship, for then the ship rises bodily with the passage of each wave crest. The observer should then take up a position in the ship so that his eye is just in line with the advancing wave crest and the horizon, when the ship is vertical in the trough. The height of eye above the ship's water line is then the height of the wave. The nearer the observer is to an amidships position the less chance will there be of the measurement being vitiated by pitching. If the ship rolls heavily it is particularly important to make the observation at the moment when she is upright in the trough. Exaggeration of estimates of wave height is mostly due to errors caused by rolling. (See Fig. A2. When the ship is rolling (b), the observer at "0" has to take up a higher position to get a line on the horizon than when she is upright (a).)

FIG. A2(a)

FIG. A2(b)

The observation of height of waves is most difficult when the length of the waves exceeds the length of the ship and their height is small. The best estimate of height can be obtained by going as near the water as possible, but even then the observation can only be rough. In making height estimates an attempt should be made to fix a standard of height in terms of the height of a man or the height of a bulwark, forecastle or well-known dimension in the ship. There is generally a tendency to overestimate the height of short waves and underestimate the height of long waves.

Estimating the height of a wave from a high bridge in a fast ship is a difficult job and much will depend on the skill and ingenuity of the observer; in many cases all one can hope for is a very rough estimate. All estimates of wave height should be made preferably with the ship on an even keel so that the observer's height of eye is consistent. The inherent difficulties already mentioned, together with the practical difficulties of estimation, make it essential that the recorded height be the average value of about twenty distinct observations. These observations should be made on the central waves of the more prominent wave groups.

Wave observations at night or in low visibility. Under these conditions the most that the observer can normally hope to record is direction and an estimate of height, or perhaps direction only, which would at least indicate the presence of waves. Such observations might be of considerable value in tropical waters in the hurricane season. It is only on very bright nights that the observation of period would be practicable.

APPENDIX B

GUIDANCE FOR OPERATION OF HIGH-SPEED CRAFT IN FOLLOWING AND STERN QUARTERING SEAS

1 General

This note has, as its primary aim, the provision of advice to mariners on what to expect and how to handle a high-speed craft in severe following and stern quartering seas. The guidance offered here is based, not only on the recent research, but also on the accumulated experience of practising mariners.

The principal hazards likely to be experienced by a high-speed craft in severe following or stern quartering seas are surfing, bow-diving and broaching.

The master will be in a better position to avoid dynamic problems if he has instruments that inform of the behaviour of his vessel and information on the sea states he is likely to encounter on the voyage. These parameters include vessel speed, heading, vertical acceleration, longitudinal acceleration, wave forecasts and current sea state.

Following seas refer to seas which are dead astern while stern quartering seas refer to wave directions between dead astern and 45° from dead astern.

Bar crossings may involve behaviours similar to a number of those outlined in this Appendix. As this guidance is of a general nature, it does not include specific information on bar crossing for which the hazards and behaviours are highly variable according to the individual circumstances. Specific information in this regard in relation to the craft and its route should be provided in the Route Operational Manual.

It should be noted that the advice given in this note is for guidance only and should augment and not replace the skill and judgement of the mariner, or the tenets of good seamanship.

Drafting Note:

> ***The Group may wish to insert, as a penultimate paragraph of this section, something along the lines "Bar crossings may involve behaviours similar to a number of those outlined below. As this guidance is of a general nature, it does not include specific information on bar crossing for which the hazards and behaviours are highly variable according to the individual circumstances. Specific information in this regard in relation to the craft and its route should be provided in the Route Operational Manual."***
> ***UK happy for this to be inserted***
> ***China: Agree***
> ***RINA: This addition is agreed.***

U.S. - Agree with the addition of this note.
Co-ordinator: Note inserted above

2 Critical behaviour in following and stern quartering seas

2.1 Trapping

Trapping can occur when the vessel is moving directly down-wave in waves whose length is roughly equal to the waterline length of the vessel. When cresting one wave, the craft will experience a reduction in resistance, which will cause it to accelerate into the trough ahead and immerse its fore-body in the next wave. If this does not result in a bow dive, the craft will experience a significant increase in resistance that will slow it down to the speed of the waves. It can be the precursor to a bow-dive.

Warning signs:

- moving at the speed of the wave, see Table 1, and
- one wave crest at the stern and another at the bow, and
- wave height greater than 4% craft waterline length
- craft becomes trapped between two successive crests.

Corrective action:

- slow down and allow the waves to draw ahead.

2.2 Surging and surfing

When a high-speed craft is moving in following seas which are directly astern and where the wave length is about the same as or greater than the vessel length, it may accelerate and decelerate in surge as the crests pass. Such surge velocities may differ by as much as 50% of the average speed and are caused by significant changes in resistance and propulsive efficiency as the waves pass. Without warning the craft may accelerate rapidly to the speed of the wave and surf. Surfing is best avoided if at all possible because of the almost total loss of control that occurs while it is in progress. Surfing can be the precursor to a bow-dive, or a broach.

Warning signs:

- large variations in craft speed at constant throttle
- craft is moving at wave speed plus or minus 10% ($^{1}/_{10}$th), see Table 1, and
- the wave length is between 1 to 2.5 times craft waterline length, and
- the craft has a slight bow-down pitch attitude, with a wave crest abaft amidships
- response to steering controls is poor
- breaking waves increase the tendency to surf.

Corrective action:

- avoid running at wave speed (see Table 1) in waves of dangerous length
- if caught in a surf wait until the critical wave has passed without attempting any major helm action
- afterwards, slow down.

2.3 Bow-diving

Bow-diving occurs when a high-speed craft buries its bow into a wave in following or stern quartering seas. This causes all way to be lost, the vessel experiences a severe bow-down pitch and the bow becomes submerged, sometimes resulting in structural damage and injury to personnel. It is particularly severe for vessels such as catamarans with a cross deck and limited residual buoyancy forward. It is different to bow immersion in head seas as the wave behind lifts the stern and worsens the situation.

Bow-diving may have a slow onset if moving at wave speed, but may be dramatic without warning if craft is moving substantially faster than the waves.

Warning signs:

If preceded by trapping (see 2.1 above):

- as for trapping, <u>and</u>
- wave height greater than about 75% ($^3/_4$) of bow freeboard when stopped, <u>and</u>
- waves from between directly astern and the quarter
- bow almost immersed to the deck or top of cross-structure.

If craft is moving faster than the waves and:

- waves from between directly astern and the stern quarter, <u>and</u>
- wave height greater than 25% ($^1/_4$) of bow freeboard when stopped, <u>and</u>
- wave length 100% to 150% of the waterline length of the craft.

Corrective action:

- avoidance by attention to the warning signs
- avoiding any trim by the bow
- slow down to less than about 70% of wave speed
- alternatively, if practicable, change course, even to head seas.

2.4 Broaching

Broaching is a severe, and often uncontrollable, yawing movement in following seas which turns the vessel beam on to the waves resulting in a dangerously heavy roll, and a sideways sliding motion down-sea. In monohulls with insufficient stability it can result in capsize. It may be preceded by surfing.

Warning signs:

- desired course slightly or appreciably across the waves, up to 45° from directly down-sea
- wave length similar to craft waterline length, or slightly shorter in quartering seas, and
- craft speed similar to wave speed plus or minus 15% ($^1/_7$th), see Table 1, and
- wave height greater than 4% craft waterline length, and
- bow-down attitude and bow burying into wave ahead
- up-sea waterjets or propellers beginning to ventilate
- severe yaw motions either side of intended course
- surfing.

Corrective action:

- avoid a diagonal course across the waves, i.e.: up to 45° from directly down-sea
- avoid running close to wave speed (see Table 1) in waves of dangerous length
- reduce speed to less than about 70% of wave speed
- after a broach, directional control is best reasserted by reducing speed.

3 Other behaviour which may occur

Masters should also be aware of the other types of behaviour that may occur, *viz*:

- loss of transverse stability due to loss of waterplane area when poised on a wave
- slamming, which can occur with high speed vessels in following seas if their speed is at least twice the speed of the waves
- synchronous rolling, which occurs in stern quartering seas when the period of the transverse components of the waves coincides with the natural roll period of the vessel
- parametric rolling, which can occur in following seas if the length of time each wave takes to pass the vessel is approximately equal to half the natural roll period
- combinations of behaviour, such as surfing which can lead to a broach or a bow-dive; both of which can lead to further severe events such as fore-deck immersion or capsize.

4 Summary

4.1 Craft speed

It is important that speed should be appropriate for the sea conditions. In a following or stern-quartering sea, it is comparatively easy to determine whether the craft is moving faster or slower than the dominant waves in daylight. At night-time, however, such assessments are not so easy.

Craft speed, it is assumed, will be known with some accuracy. If not, then, when moving at or near the dominant wave speed (and possibly trapped or in danger of surfing), pitch and heave motions will be considerably reduced, but surge motions will be significantly increased.

A rough idea of the speed of the dominant waves in a given sea state can be obtained from Table 1, according to the type of waters in which the vessel is operating.

Sig. wave height (m)	**1**	**2**	**3**	**4**	**5**	**6**
Coastal waves	15 - 18	17 - 23	19 - 27	20 - 30	21 - 33	23 - 35
Ocean waves	19 - 29	21 - 31	25 - 35	29 - 39	32 - 42	36 - 46

Table 1 – Tabulated typical wave speeds (knots)

4.2 Wave length

It can be seen from the advice given above that wave length in relation to the waterline length of the craft is also important in assessing the vulnerability to adverse behaviour. It is therefore important to monitor the length of the waves in which the craft is being operated.

4.3 Tabular summary

Table 2 summarizes the guidance given in this note.

Behaviour	Critical craft speed		Critical wave length		Critical wave heights
Trapping	$\approx V_W$	and	$\approx L_S$	and	$> 4\% \ L_S$
Surfing	$\approx V_W \pm 10\%$	and	$\approx 1 \rightarrow 2.5 \ L_S$	and	$> 4\% \ L_S$
Bow-diving (slow)	$\approx V_W$	and	$\approx L_S$	and	$>75\%$ F
Bow-diving (sudden)	$> V_W$	and	$\approx 1 \rightarrow 1.5 \ L_S$	and	$> 25\%$ F
Broaching	$\approx V_W \pm 15\%$	and	$\approx L_S$	and	$> 4\% \ L_S$

Table 2 – Summary of guidance in following and quartering seas

Key:	≈ is approximately equal	± is plus or minus
	> is greater than	V_W is wave speed
	L_S is ship length	F is bow freeboard when stopped

APPENDIX C

RISK ASSESSMENT IN RELATION TO WAKE WASH WAVES

Drafting Note:
The delegation of Greece, supported by the Bahamas, commented at DE 51 that this Appendix goes beyond Code requirements and so is not required. The Group was instructed to take such comments into account. Any comments on the inclusion or otherwise of this Appendix would therefore be welcome.
UK believes that this is useful detail that should be retained within these Guidelines. I think that this will prove to be a useful tool to Administrations if they believe that wake wash is a problem in their waters and needs to be addressed. It is slightly outside the remit of the Code but the CG was however tasked to consider impact on "those affecting the safety of persons outside the craft", under which this fits perfectly. In fact it seems to be the only item to which this guide could apply. Please note though that the UK feel that it is important for the text of the Code or preferably a document such as these Guidelines under discussion, to refer to the requirements that the UK have which underpin the wake wash risk assessments: The UK also require that officer of the watch and the master follow this aspect of the passage plan rigidly in shallow water during each voyage (including transit voyage / scheduled voyages) and that they are each properly trained and Type Rated in order that they understand it in full and the implications of deviating from it. The UK should ask that note be made of this training requirement for Type Rating and to request update to the IMO Guidelines for instances where wake wash is considered.
RINA: RINA agrees with the retention of this appendix. Clause 1.4.61 of the Code specifically permits (encourages?) Administrations to include "such other parameters as the Administration may require in considering the type of craft in the area of operation". This appendix is guidance and is not mandatory. The following amendments are suggested with a view to improving the understandability of this annex. Further input is awaited from Prof. Whittaker of Queen's University, Belfast, who led research into this subject on behalf of the UK MCA. This will be submitted at the next round. Recognising that many Administrations may not have expertise in this area, RINA suggests that it is important that this annex is not eliminated. However, if it is considered necessary, a condensed version could be developed.
Australia: Support Greece and the Bahamas. Most port States have no concern about wave wake wash, but the role of the port State(s) outlined in 1.9.3 of the Code with regard to setting the conditions of the Permit to Operate can be applied where a port State has such concerns. Is this substantial change actually within our remit, as there is no specific reference to wave wake wash within the HSC Code, so are we adding completely new requirements? Propose deletion of this Appendix and footnote 2 in relation to para 7.3, since wave wake wash is just one of three possible areas of concern mentioned in the relevant sentence of para 7.3.
Co-ordinator: Further comments invited in view of support for deletion of the Appendix by Greece, Bahamas and Australia. Pending the Group's decision on this, the draft text has been amended based upon the revisions submitted by RINA. The extent of the amendments made renders "track-changing" impractical, but can be gauged from the RINA submission.

1. Introduction

The waves generated by the high-speed craft has been identified as a potential hazard to shorelines, structures, other vessels, and persons who may be at or near the shorelines, particularly when the HSC is operating in relatively shallow water.

These guidelines apply where the flag and/or coastal State Administration requires the Company (as defined in the ISM Code) to undertake a risk assessment of the passage plan as part of the requirements for issue of the Permit to Operate certificate. This non-mandatory guidance is provided on the processes and documentation recommended for the risk assessment.

2. Risk Assessment for High-Speed Craft

Where the Administration requires a Risk Assessment of the passage plan with reference to wake wash, the Company should propose a route and speed profile that minimises the effects on the local shoreline and to local users. The risk assessment may be applied to all HSC operating in a coastal State's waters and should highlight any areas likely to be affected by wake wash and any subsequent action taken to reduce those waves and their effects.

Where wake wash is of concern, the master of an HSC undergoing any voyage, whether transit or scheduled, should be responsible for having a passage plan in place which includes a risk assessment with respect to wake wash.

3. Guidance

Guidance is given below on how to conduct such an assessment.

Attention is also drawn to:

(a) UK MCA Research Project 420 – "Investigation of High-Speed Craft on Routes near to land or enclosed Estuaries" and in particular Table 8.1 of the report Wash Characteristics gives four types of Wash Classification.

(b) UK MCA Research Project 457 – "A physical study of Fast Ferry Wash Characteristics".

(c) UK MCA, Instructions for Guidance of Surveyors – 2000 HSC Code, Appendix D – Risk Assessment of Passage Plan.

(d) PIANC Project Guidelines for managing wake wash for High-Speed Vessels, Marcon Report of WG 41, 2003.

(e) Danish Maritime Authority HSCAG 6/97 – "Technical Investigation of Wake Wash from Fast Ferries"

(f) UK Engineering and Physical Sciences Research Council report GR/R21165/01 - Ship's Wash Impact Management

4. Outline Form of Assessment

The HSC Code is a risk-based document and the solution to managing wake wash is identifying an appropriate risk-based solution. The Guidelines for the Application of Formal Safety Assessment for use in the IMO Rule-Making Process (MSC/Circ. 1023) offer a structured methodology for undertaking the risk assessment. These guidelines offer an overview of the techniques involved and a format for a final report. The format of the report is that recommended by IMO.

5. Wake Wash Background

Wake Wash means the waves produced by the vessel due to its movement through the water. These waves are associated with the transmission of energy away from the vessel. For HSC operating at high speed, their generation takes place in a different speed-length regime than for conventional ships and their generation, propagation and impact are affected more by water depth than those typically produced by conventional ships.

The common factor for HSC such as passenger ferries is that the power propulsion system delivers a considerably higher engine output per person transported compared to slower conventional ferries. The need for higher power has the consequence of a type of wake wash which may lead to increased hazards to shorelines, structures, other marine vessels and activities of people, e.g., bathing beaches. When a craft makes way through the water, wake wash is generated as a result of the change in pressure along its hull. The actual wave pattern, height and frequency, depend on the craft hullform, size, depth of the water, topography of the seabed and the HSC's speed.

The waves are largest at the so called "critical speed" (a ratio between the ships speed and the depth of water) which should be avoided. A HSC should operate at a speed above or below critical speed as the waves at these levels are more moderate. In shallow water, wake wash waves produced by the HSC distinguish themselves significantly from those generated by the conventional ships in that they have a much longer period and appear very suddenly along the coastline. HSC typically generate a wave pattern comprising of groups of long period bow divergent waves and short period stern divergent waves.

The long periodic waves cannot normally be observed near the route of the craft due to the flatness of the wave profile, but these waves usually cause problems in the shallow water near the coasts because their height increases when the depth decreases. At the same time, the wavelength decreases resulting in increasing the wave steepness and when it exceeds a certain limit, the wave will break. Although the highest wave produced by a fast ferry is at the depth critical speed, operators minimise the time spent in this region and by carefully selecting the locations for acceleration and deceleration, the impact on the shore can be localised and the position of its contact controlled. However, if a ferry operates at super-critical speed in a confined estuary, the inherent characteristics of the initial waves are unavoidable, potentially affecting substantial lengths of coastline.

Wake wash is classified as subcritical, critical or supercritical in terms of the depth Froude number F_{nh} which describes the ratio of the vessels speed to the wave propagation velocity in shallow water and $F_{nh} = Vs/\sqrt{(g.h)}$ where Vs is the ship speed in metres per second, g is the acceleration due to gravity in m/s2 and h is the water depth in metres: for the purpose of classification "sub-critical" means approximately $F_{nh} <1$, "critical" means the band approximately between $F_{nh} = 0.85$ to 1.15 and "supercritical" means approximately $F_{nh} >1$.

Small HSC, primarily passenger-only vessels typically have service speeds above a length Froude number (F_{nl}) of 1.0. As these vessels accelerate and decelerate they pass through a transition speed (sometimes referred to as "hump speed") where wake wash is at a maximum for conditions other than operating in critical depth. For most vessels, this occurs at a F_{nl} between 0.55 and 0.6. At speeds above this transition speed, wake wash wave heights decrease with increasing speed.

It can be shown that operation at a length Froude number of 0.9 or more corresponds to critical water depths greater than about half the length of the vessel. With respect to the generation of critical waves at such water depths, the shallow water effect for typical HSC becomes negligible. However this does not mean that the subsequent propagation of these wash waves into shallow water should be ignored.

It is known that turning in shallow water (wake wash focused at the inside of the turn), changes in speed and acceleration and deceleration through the transition speed can cause potentially hazardous wake wash. It is also known that the effects of these powerful waves can become focused by HSC vessels crossing paths, e.g. sisterships on the same route. These known factors can be used to an advantage in the risk assessment and the approach angle (with respect to the coastline and seabed topography etc.) can be modified, the vessel can be stopped, a change of speed can be used, timetable adjusted, etc. to minimise the effects of the wash.

From experience, it is known that wake wash from vessels operating at reduced power, e.g. on 3 of their normal 4 engine capacity (asymmetric powering), are prone to generating an increased wash. This is not due to speed reduction alone but also to the "crabbing" motion of the hull when asymmetric powering is used. When considering way-points to reduce speed the following should be considered:

- because of the reduced thrust available the vessel will take longer to transit the critical depth speed range or may be unable to pass through this range and become trapped near the critical speed. In the latter case, speed should be reduced to a sub-critical depth Froude number zone below 0.8.

- the vessel may be operating at less than the optimum hull resistance.

It is important to note that the potentially hazardous wake wash generated by high speed craft is not unique to HSC and conventional hullforms can also be prone to the phenomenon.

6. Hazard Identification and Risk Assessment Format

The hazard identification process should, of necessity, consider:-

- Where a (geographically) hazard occurs;
- Over what timeframe the hazard occurs;
- The physical properties of the hazard;
- Who is at risk from the hazard (data on other craft population, shorelines, structures and activities on or near the shoreline);
- Coarse analysis of possible outcomes of hazards to other craft;
- Ranking of hazards: and
- Identify highly sensitive areas, e.g. bathing beaches, marinas, vulnerable coastline, etc.

The risk assessment should identify the distribution of risk (frequency and consequence) across the already identified hazards and identify those areas of high risk, which need addressing.

When conducting route planning and risk assessment, operators should:

- Identify and document control measures to restrict the hazard from wake wash
- Accelerate and decelerate through the transition speed as rapidly as possible.
- Choose locations and courses for acceleration and deceleration such that transition speed wake wash will be directed into minimally harmful areas.

Risk assessment may be performed on the basis of operational experience on the route in question, assisted by theoretical investigation, where appropriate.

7. The Permit to Operate

The Operational Criteria of the Permit to Operate may include:

1. A full Risk Assessment of the Passage Plan with reference to wake wash must be carried out.
2. Any likely areas of adverse wake wash impact to be identified and action taken to reduce it.
3. The vessel to be operated in accordance with the control measures identified in the risk assessment.

8. Pro Forma for letter of Acceptance of the Risk Assessment for Passage Plan

It is recommended that the Administrations use the following wording in a letter to the vessel's Operator to confirm acceptance of the risk assessment of the passage plan with respect to wash and wake:

> "The Risk Assessment for the Passage Plan of Vessel ……………………………......................
>
> On Route of ………………………...…………to……………………………………………
>
> Has been noted and fulfils the requirement of Clause Number ……………………………….. of Operational Criteria of the Permit to Operate.
>
> If there are any or a number of complaints of wake wash noted in a particular area the Operator will be approached and requested to revisit and modify as necessary that part of the Risk Assessment for the Passage Plan. "

9. Training Aspects

The Administration concerned in relation to the wake wash hazard may require that the Master and all officers having an operational role on an HSC (comments apply generically to either 1994, 2000 HSC Code or DSC Code) vessel should complete detailed training with respect to wake wash generation in order to gain Type Rating. This training should enable the person to fully understand the possible impact of inappropriately operating at speed in shallow water; of operating at a course and speed different from that resulting from risk assessment of the passage plan; the possible hazards caused by turns; and operating under asymmetric powering.

References

Section 1:

UK MCA, Instructions for Guidance of Surveyors – 2000 HSC Code, Chapter 1, section 1.9, *available at www.mcga.gov.uk > Ships and Cargoes > Ship Regulation and Guidance > Guidance of Surveyors.*

Section 3:

UK MCA, Instructions for Guidance of Surveyors – 2000 HSC Code, Appendix D, *available at www.mcga.gov.uk > Ships and Cargoes > Ship Regulation and Guidance > Guidance of Surveyors.*

PIANC publication, Project Guidelines for Managing Wake Wash for High-Speed Vessels, Marcom Report of WG 41, 2003. *This report may be ordered from the PIANC Web Site at* *www.pianc-aipcn.org/publications/reports-article.php?id=2000411*.

UK Research Reports on Projects 420 and 457, *available at www.mcga.gov.uk > About Us > What we do > Research*

Danish Maritime Authority HSCAG 6/97 – "Technical Investigation of Wake Wash from Fast Ferries" *Trying to identify where available.*

UK Engineering and Physical Sciences Research Council report GR/R21165/01 - Ship's Wash Impact Management, *Trying to identify where available.*

Section 4:

UK HSE publication on Reducing Risks Protecting People" (R2P2)

UK HSE "Marine Risk Assessment Offshore Technology" report 2001/063

*UK HSE publications are available at www.hse.gov.uk/pubns/.*UK MGN 20(M+F) "Advice on Risk Assessment – Implementation of EC Directive 89/391", *available at www.mcga.gov.uk > Ships and Cargoes > Ship Regulation and Guidance > M Notices*

ANNEX

Example Sheet of a Risk Assessment

(shown on next page)

HIGH SPEED CRAFT ROUTE RISK ASSESSMENT

Assessment Number……………………………

This record considers the above named vessel route plan from ………………......….. to ……………........……..

And assesses the risk to other mariners, persons on the shoreline and the environment as a result of waves or wash generated by the vessel.

Date……………………………………………Assessment Leader ………………..…………….

Passage Plan sector from …………………………………to:……………………………………

PERCEIVED HAZARD OR RISK

(example) Critical waves onto Killiney beach, Bullock Harbour, Sandycove, Fortyfoot.

RISK ASSESSMENT (TICK LEVEL)

HAZARD SEVERITY / **LIKELIHOOD OF OCCURRENCE**

	5 VERY HIGH	Multiplied By		5 VERY LIKELY	=	
X	4 HIGH		X	4 LIKELY		
	3 MODERATE			3 QUITE POSSIBLE		16
	2 SLIGHT			2 POSSIBLE		
	1 NIL			1 UNLIKELY		

CONTROL MEASURES NECESSARY OR IMPLEMENTED

(example)

1 Follow course line via South Burford Buoy for bank to absorb wave/wash (Mats Feldtmann 20/5/99 p8/9 & SMSO #7)
2 Operate Craft with minimum trim (Mats Feldtmann 20/5/99 p19 7.8.3 & SMSO #50)
3. Reduce speed quickly to minimise time in critical speed zone (Mats Feldtmann 20/5/99 p17 7.8.1 & SMSO #50)
4. Avoid course alteration during slowdown (Mats Feldtmann 20/5/99 p 17 7.8.1 para3 & SMSO #50)
5. If speed below 34kts at 1 mile from Kish maintain speed at subcritical (ACH email 22/7/99 Mats Feldtmann 20/5/99 p40 14.3.2)
6. Make early speed reduction if exceptional conditions prevail (Mats Feldtmann 20/5/99 p21 7.10.2 & SMSO #50)

RESULTS AFTER RECOMMENDATIONS IMPLEMENTED

HAZARD SEVERITY / **LIKELIHOOD OF OCCURRENCE**

	5 .VERY HIGH	Multiplied By		5 VERY LIKELY		
	4 HIGH			4 LIKELY		
	3 MODERATE			3 QUITE POSSIBLE	=	4
X	2 SLIGHT		X	2 POSSIBLE		
	1 NIL			1 UNLIKELY		

REMARKS

(example)

(Matts Feldtmann 20/5/99 p23)

RISK RATING	ACTION AND TIMESCALE
1 – 5 TRIVIAL	No action is required
6 – 10 TOLERABLE	No additional controls are required. Monitoring is required to ensure that the controls are maintained
11 – 15 MODERATE	Efforts should be made to reduce the risk, but the costs of prevention may be taken into account. Risk reduction measures should be implemented within a defined time period. Where the moderate risk is associated with extremely harmful consequences, further assessment may be necessary to establish more precisely the likelihood of harm as a basis for determining the need for improved control measures.
16 – 20 SUBSTANTIAL	Voyage should not be started until the risk has been reduced. Considerable resources may have to be allocated to reduce the risk. Where the risk involves work in progress, urgent action should be taken.
21 – 25 INTOLERABLE	Voyage not to be started or continued until the risk has been reduced. If it is not possible to reduce risk even with unlimited resources, passage has to remain prohibited.