Calculation of stability around the weakest heeling axis with PIAS

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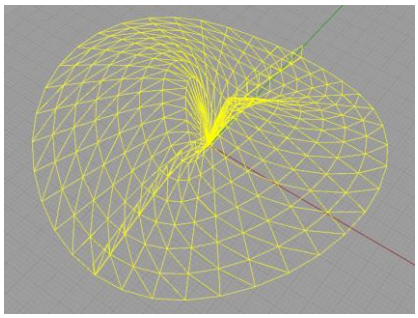
PIAS, as many other stability programs, has from its conceptualization in the 1980s determined the intact and damage stability (or, to be more precise, the GZ) with respect to centerline plane. That is not always correct, in particular with hull shapes which are significant asymmetrical in longitudinal direction the GZ should be determined with respect to a rotated plane (rotated around a vertical axis). Occasionally, people have inquired for a possible extension of PIAS towards the effects of stability around the axis of weakest stability, and the recurring reply of SARC was that this would certainly be feasible, and could be produced on order. In 2017 that was finally materialized, so, at the present moment, PIAS one out of four alternatives can be selected to compute stability:

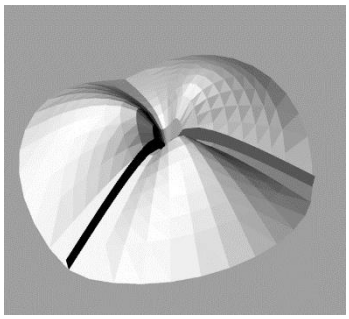
- With fixed trim (only available for intact stability).
- With the free-to-trim effect (a.k.a. the *constant LCB* method).
- With free-to-trim effect, including the effect of VCG on trim.
- Heeling around the weakest axis (the axis of minimum GZ).

With this function enabled, for all angles of inclination, GZ is computed around a series of horizontal heeling axes, heeling from 0° (around a longitudinal axis, heeling to SB), via 90° (around a transverse axis, heeling to the stern), 180° (around a longitudinal axis, heeling to PS), 270° (around a transverse axis, heeling to the stem) to 360=0°. These GZ values can be plotted in a "GZ-surface", from which an example is depicted at the right. In this surface two paths of least GZ can be recognized —indicated by a ribbon in the figure — which correspond to the conventional GZ-curves. These GZ-curves can be for heel to SB & PS, or to stern & stem, or to any other direction, dependant from the orientation and L/B ratio of the barge. For this simple barge example the axis around which the vessel heels is constant for all angles of inclinations, but for a realistic vessel this axis will change will the angle of inclination.



GZ surface for a slender rectangular barge

Another example concerns a triangular barge, where three paths of least stability are present, see the figure at the right. In order to be compared with stability requirements —which are usually related to a single GZ-curve (which can contain two branches, one for each side of heel)— the two paths of least GZ are destilled from this surface.



GZ surface for a triangular barge

After the GZ-curve has been derived from the GZ-surface, it is processed and used in the conventional way, i.e. plot of the GZ-curves, verify against the stability criteria, and determine the maximum allowable VCG. In PIAS this *stability around the axis of weakest stability* feature is used wherever potentially usefull; for intact and damage stability, and in combination of other specific stability analyses, such as hopper dredger stability[1]. Some types of calculations are inherently incompatible with the concept of *weakest axis stability*, such as *cross curves*, so the are disabled in PIAS when this setting is switched on.

More background material, examples, verifications and discussions on choices and potential future enhancements can be found in the 16-page document *Stability around the weakest axis in PIAS —Explanatory notes* which is available on request at SARC.

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[1] According to dr-68 or other specific open hopper stability requirements.