PARAMETERS INFO

Bounding Box

Selection of departure and arrival place must be complemented by provision of extra information about so called “bounding box” for route computation, see Figure 1.

Indeed, both geodetic and optimal routes are searched in a rectangular box having departure and arrival place as vertexes (red box). However, this may lead to suboptimal solutions or even to no solutions. For example, in the case depicted in Figure 1., departure and arrival place are not connected within the red domain. Thus, the user should adjust the size of a buffer zone around the red domain by setting the values of the variables:

- ***Delta Lat. Up***
- ***Delta Lat. Down***
- ***Delta Lon. Left***
- ***Delta Lon. Right***

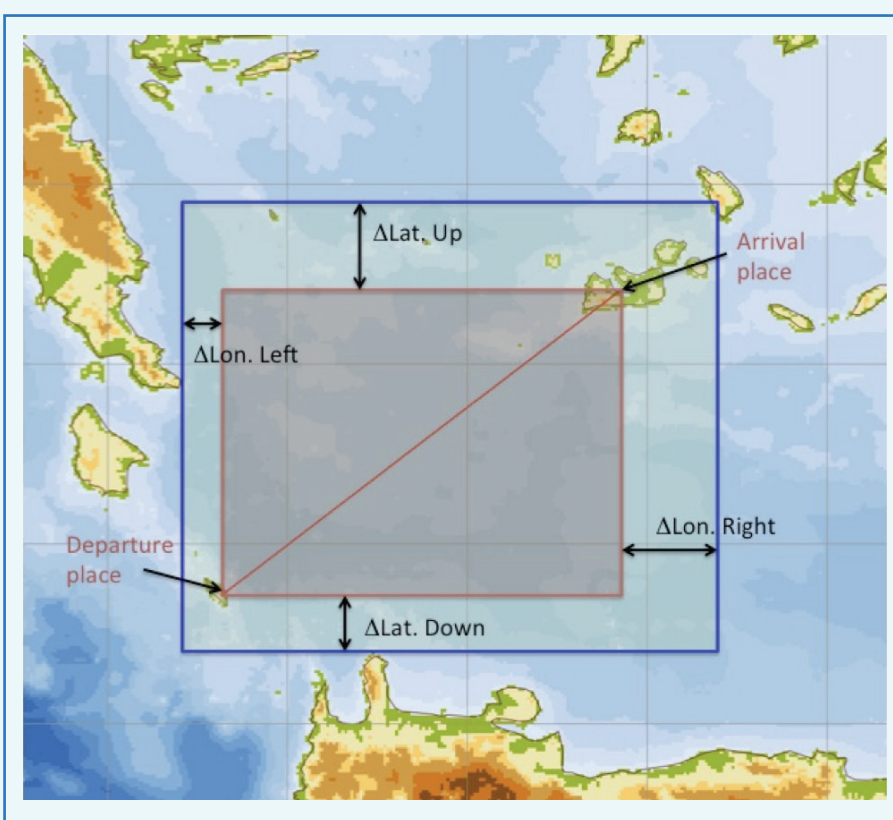

Figure 1 Graphical explanation of the meaning of the Bounding Box parameters.

Safety Constraints

- ***Parametric Rolling***

The development of the occurrence of parametric roll is caused by periodic stability changes occurring with a certain frequency - about twice per roll period. If the ship is rolled while on the wave trough, increased stability provides stronger pushback, or restoring moment. As the ship returns to the upright position, its roll rate is greater, since there was an additional pushback from the increased stability. If at that time, the ship has the wave crest at midship, the stability is decreased and the ship will roll further to the opposite side because of the greater speed of rolling and less resistance to heeling. Then, if the wave trough reaches the midship section when the ship reaches its maximum amplitude roll, stability increases again and the cycle starts again [1].

- ***Pure Loss of Stability***

A large wave is approaching from the stern, while the ship is sailing with relatively high speed in following seas. If the celerity (speed) of the large wave is just slightly above the ship speed, the time duration for the large wave to pass the ship may be long. Once the crest of the large wave is near the midship section of the ship, its stability may be significantly decreased. Because the wave celerity is just slightly more than ship speed, the condition of decreased stability may exist long enough for the ship to develop a large heel angle, or even capsize [1].

- ***Surf Riding/ Broaching-to***

Broaching-to is a violent uncontrollable turn, occurring despite maximum steering effort in the opposite direction. As with any other sharp turn event, broaching-to is frequently accompanied with a large heel angle, which may lead to partial or total stability failure. Broaching-to occurs in following and stern-quartering seas.
Broaching-to is usually preceded by surf-riding. Surf-riding occurs when a wave, approaching from the stern, captures a ship and accelerates its to the wave speed (wave celerity). While surf-riding, the wave profile does not vary relative to the ship. Most ships are directionally unstable in the surf-riding situation; this leads to the uncontrollable turn, defined as broaching-to (or often, just “broaching”). [1]

Ship parameters

- ***Engine power***

  Maximum available propulsion power. Units: hp

- ***Cruise speed***

  Maximum sustained ship speed. Units: knots

- ***Length***

  Ship length at the waterline. Units: meter

- ***Beam***

  Ship width at the waterline. Units: meter

- ***Draught***

  Minimum vertical clearance for safe operation of the vessel. Units: meter

- ***Metacentric Height***

  Distance between the centre of gravity of a ship and its metacentre [2]. Units: meter

- ***Natural roll period***

  Period of the undamped roll motion of the vessel. Units: seconds

Routes

Two routes are provided from the computational data center:

- ***Geodetic route***

  This is the geometrically shortest route between given departure and arrival place. It may not be the quickest and may be unsafe with respect to any of the criteria for ship intact stability (s. below).

- ***Optimal route***

  This is the shortest route in terms of navigational time, satisfying the safety constraints the user decides to check (default is: all constraints checked). Thus, it may be longer than the geodetic route.

Output variables

- ***Engine throttle***

  It is the fraction of engine brake power used. 100% means that the power setting corresponds to the “engine power” value.

- ***Ship speed***

  It is the speed sustained in a given sea state and throttle setting.

- ***Ship course***

  It is ship direction of advancement, measured clockwise from North (e.g.: 0 deg. means northbound, 90 deg. eastbound).

- ***Significant wave height***

  Significant wave height is the mean height of the highest third of the wave distribution.

- ***Period of Encounter***

  It is wave period as seen from the moving vessel. It may be smaller or larger than wave period. It may even be negative, if waves are met from stern. If encounter wave period is very large (say >50 seconds), two successive wave crests are met after a very long time: this means that vessel is moving at a speed similar to wave celerity.

Bibliography

[1] Belenky, V., Bassler, C. G., and Spyrou, K. J.: **Development of Second Generation Intact Stability Criteria**, *Tech. rep., DTIC Document, 2011*.

[2] http://en.wikipedia.org/wiki/Metacentric_height