Claims

1. A computer implemented method of generating a new body design for a new vehicle, the method comprises:
   (a) providing a single initial body design of a vehicle in a two-dimensional space with a plurality of frame lines;
   (b) selecting a first boundary frame line of the single initial body design and a second boundary frame line of the single initial body design;
   (c) selecting a first reference frame line between the first boundary frame line and the second boundary frame line;
   (d) selecting a morphing parameter, wherein the morphing parameter is a rate of change between the first reference frame line and the first boundary frame line and/or the second boundary frame line;
   (e) modifying the single initial body design from the first reference frame line towards the first boundary frame line and/or from the first reference frame line towards the second boundary frame line based on the morphing parameter; and
   (f) generating the new body design.

2. The method according to claim 1 wherein there is at least one intermediate frame line between the first reference frame line and the first boundary frame line and/or the first reference frame line and the second boundary frame line, and the method further comprises adjusting the at least one intermediate frame line based on a modified morphing parameter.

3. The method according to any one of claims 1 to 2 further comprises selecting a third boundary frame line of the single initial body design; selecting a second reference frame line between the second boundary frame line and the third boundary frame line; selecting a second morphing parameter, wherein the second morphing parameter is a rate of change between the second reference frame line and the second boundary frame line and/or the third boundary frame line and modifying the single initial body design from the second reference frame line towards the second boundary frame line and/or towards the third boundary frame line based on the second morphing parameter.

4. The method according to any one of claims 1 to 3 wherein the first, second, and/or third boundary frame lines is a non-terminal frame line.

5. The method according to any one of claims 1 to 4, wherein the first boundary frame line is selected proximal to a first end of the single initial body design and the second boundary frame line is selected proximal to a second end of the single initial body design, the second end being opposite to the first end.

6. The method according to claim 5, wherein the first end is a forward section of the single initial body design, the second end is an aft section of the body design, and the third boundary frame is selected proximal to the middle of the single initial body design.

7. The method according to any one of claims 1 to 6, wherein the morphing parameter is randomly selected.

8. The method according to any one of claims 1 to 7, wherein the first reference frame line and/or the second reference random frame line is/are randomly selected.

9. The method according to any one of claims 1 to 8, wherein modifying the single initial body design is based on the following:

$Y(t = x_R \times W)_{R_{x,z}} = (1 - (t \times S_{TS})) \times Y_{S_{x,z}} + (t \times S_{TS}) \times Y_{T_{x,z}}$,

where $W = 0.02 \times (x - x_{AB})$ when $x_{AB} \leq x \leq x_{MB}$ and $W = 0.02 \times (x - x_{MB})$ when $x_{MB} \leq x \leq x_{FB}$;

$Y(t = x_A \times \omega)_{A_{x,z}} = (1 - (t \times S_{TS})) \times Y_{S_{x,z}} + (t \times S_{TS}) \times Y_{T_{x,z}}$,

where $W = 0.04 \times (x - x_R)$ when $x_R \leq x \leq x_{MB}$ and $x_R \leq x \leq x_{FB}$,

$W = 0.04 \times (x_R - x)$ when $x_{AB} \leq x \leq x_R$, and

$W = 0.04 \times (x - x_{MB})$ when $x_{MB} \leq x \leq x_R$;

subject to $0.2 \leq t \leq 0.8$ and smoothing factor, $S_{TS} = 1 - \frac{Y_{TS}}{B_{max}}$,

where $Y(t)_{R_{x,z}}$ is the new *Y* value for the reference curve at corresponding *x* and *z* coordinates, $Y(t)_{A_{x,z}}$ is the new *Y* value for adjacent curves at corresponding *x* and *z* coordinates, $Y_{S_{x,z}}$ is the *Y* value for the reference (source) curve at corresponding *x* and *z* coordinates and $Y_{T_{x,z}}$ is the *Y* value for the boundary (target) curve at corresponding *x* and *z* coordinates. x_A is the x coordinate of the adjacent frame between the reference frame and boundary frames, $x_{F/AB}$ is x frame at the forward or aft boundary section, x_R is x frame at the reference frame section and x_{MB} is x frame

at the mid boundary section. W is the weightage, Y_{TS} is the Y value of the transition section between the two boundaries and B_{max} is the maximum ½ breadth.

10. The method according to any one of claims 1 to 9, wherein the vehicle is a ship.

11. The method according to any one of claims 1 to 10, wherein providing the single initial body design in a two-dimensional space with a plurality of frame lines comprises providing dimensions of the single initial body design in a two dimensional offset table and mapping the dimensions in the two dimensional offset table into a two dimensional line plan to obtain the plurality of frame lines.

12. A computer implemented method of generating a new set of body designs for a new vehicle, the method comprises:
    (a) providing a set of body designs of a vehicle;
    (b) evaluating each body design in the set with respect to at least one objective function;
    (c) performing a crossover combination of a plurality of body designs from the set to provide a plurality of single initial body designs based on a crossover rate, wherein the crossover rate is a probability of the combination occurring;
    (d) providing each of the plurality of single initial body designs in a two-dimensional space with a plurality of frame lines;
    (e) selecting a first boundary frame line of each of the single initial body designs and a second boundary frame line of each of the single initial body designs;
    (f) selecting a first reference frame line between the first boundary frame line and the second boundary frame line;
    (g) selecting a morphing parameter, wherein the morphing parameter is a rate of change between the first reference frame line and the first boundary frame line and/or the second boundary frame line;
    (h) modifying each of the single initial body designs from the first reference frame line towards the first boundary frame line and/or from the first reference frame line towards the second boundary frame line based on the morphing parameter and a mutation rate, wherein the mutation rate is a probability of applying the morphing parameter to modify the single initial body design;
    (i) generating a plurality of new body designs;
    (j) evaluating the plurality of new body designs based on the at least one objection function;

(k) ranking the body designs in the set of body designs and in the plurality of new body designs based on the evaluation of the at least one objective function; and

(l) generating a new set of body designs based on the ranking.

13. The method according to claim 12 further comprises selecting the plurality of body designs randomly from the set of body designs to perform the crossover combination or selecting the plurality of body designs based on the evaluating step to perform the crossover combination.

14. The method according to claim 13, further comprises rescaling at least one of the body designs in the selected plurality of body designs prior to performing the crossover combination.

15. The method according to any one of claims 12 to 14, wherein ranking the body designs comprises sorting the body designs in the set of body designs and the plurality of new body designs to determine at least one Pareto front; measuring a distance between each body design in each of the at least one Pareto front; and ordering the body designs in the set of body designs and the plurality of new body designs based on the at least one Pareto front and the distance between the body designs in each Pareto front.

16. The method according to any one of claims 12 to 15 further comprises repeating steps (c) to (l) using the new set of body designs until convergence of the body designs or a maximum number of iterations is reached.

17. The method according to any one of claims 12 to 16, wherein the at least one objective function is any one selected from the group consisting of manoeuvrability, resistance, seakeeping, stability, and structural strength.

18. The method according to any one of claims 12 to 17, wherein the set of body designs comprises a plurality of existing body designs.

19. The method according to claim 18, wherein the set of body designs comprises at least one modified body design obtained by interpolating and/or extrapolating a first existing body design and a second existing body design.

20. The method according to claim 19, wherein each of the first existing body design and the second existing body design is represented in a two dimensional plane at a plurality of locations along a third dimension perpendicular to the two dimensional plane.

21. The method according to any one of claims 12 to 20, wherein the crossover rate and/or mutation rate is at least 0.5.

22. The method according to claim 21, wherein the crossover rate and/or mutation rate is at least 0.7.

23. The method according to any one of claims 12 to 22, wherein the new set of body designs has the same number of body designs as the set of body designs.

24. A method to build a vehicle, the method comprises obtaining the new body design for a vehicle according to any one of claims 1 to 11 or obtaining the new set of body designs for a vehicle according to any one of claims 12 to 23, and manufacturing the vehicle based on the new body design or the new set of body designs.

25. A non-transitory computer readable medium comprising instructions which, when executed by a computer, cause the computer to perform a method according to any one of claims 1 to 23.