

A Method of Manufacturing A Composite Vehicle Mount

FIELD OF INVENTION

The invention relates to a method of manufacturing a composite vehicle mount.

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BACKGROUND

An example objective of aircraft design may be to allow easy assembly and dismantling of the aircraft. In a modern context this allows storage in a reduced space or portability in disassembled form.

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Prior art approaches at solving this problem include foldable or detachable modules. Commonly, where a module is provided as removable for disassembly, the attachment mechanism must be made robust. Such attachment mechanisms may add weight to the aircraft, which lowers load carrying capacity and/or increases fuel consumption.

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Unmanned aerial vehicles (UAV), for example, may be used for surveillance or monitoring capabilities in remote or demanding locations. It may therefore be desirable to provide a UAV that is easily disassembled and portable yet lightweight.

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Other vehicles may face similar problems with assembly, disassembly and/or storage.

Furthermore, since conventional attachment mechanisms used in the modular aircrafts / UAV are usually machined metallic parts, they may add weight to the aircraft which, in turn, increases costs. Attachments mechanisms having higher strength to weight ratio are important in reducing the overall weight and manufacturing costs of such modular aircrafts / UAV.

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A need therefore exists to address at least one of the above problems.

SUMMARY

In accordance with a first aspect of the present invention there is provided a method of manufacturing a composite vehicle mount, said method comprising the steps of providing a mould structure corresponding to the shape of the vehicle mount; filling corners and areas corresponding to the mould joints with fillers; damping one or

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more layers of a composite material with resin; stacking the damped layers of composite material on the mould structure, including positioning one or more layers of balsa wood in between the damped layers of composite material; curing the stacked layers to form the composite vehicle mount; removing the mould structure; and trimming and smoothening the composite vehicle mount.

Before the step of curing, the method may further comprise closing and fastening the mould structure with a mould cover; and removing the excess resin between the stacked layers.

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The excess resin between the stacked layers may be removed through channels provided in the mould structure.

The filler may comprise chopped carbon fiber strands.

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Said composite material may comprise one or more of a group consisting of carbon fiber, fiberglass, Kevlar and machined aluminium.

An end of line may be inscribed on the mould structure and transferred onto the formed composite vehicle mount.

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After curing, edges of the composite vehicle mount may be smoothened to a desired end of part (EOP) line inscribed on the mould structure and transferred onto the formed composite vehicle mount.

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The curing may be performed at ambient temperature for 23 hours or below 80°C for 6 hours.

The composite vehicle mount may comprise a track or a track follower of a unmanned aerial vehicle (UAV) or a modular aircraft.

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BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described with reference to the enclosed drawings, in which:

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Figure 1 is a perspective view of an aircraft;

Figures 2a, 2b and 2c are perspective views showing operation of a track and track follower assembly;

Figures 3a and 3b are respectively a perspective and sectional views showing the track follower attached to a propulsion module;

Figures 4a, 4b and 4c are respectively a perspective, front and side views of the track follower according to an example embodiment;

Figure 5 is a perspective view showing the track attached to a centre wing/fuselage;

Figures 6a, 6b and 6c are respectively a perspective, front and side views of the track according to an example embodiment;

Figures 7a and 7b are perspective views of a tapering track follower and track assembly, according to a further embodiment;

Figure 8 is a cross sectional view of an embodiment of a composite track follower;

Figure 9 is a cross sectional view of an embodiment a composite track;

Figure 10 is an exploded perspective view of a mould for manufacturing the composite track follower of Figure 8;

Figure 11 is a cross sectional view of the mould of Figure 10 together with the composite track follower of Figure 8;

Figure 12 is an exploded perspective view of a mould for manufacturing the track of Figure 9; and

Figure 13 is a cross sectional view of the mould of Figure 12 together with the track of Figure 9.

Figure 14 shows a flow chart illustrating a method of manufacturing a composite vehicle mount in an example embodiment.

DETAILED DESCRIPTION

In an example embodiment, an aircraft is provided with attachable or removable modules. For example, the prime mover or propulsion module may be mounted in a sliding manner to the centre wing or fuselage. One application for such an embodiment is use in a modular UAV.

Embodiments of the present invention provide a method of manufacturing composite vehicle mount (i.e. track and track follower), wherein the manufactured tracks are individual unitary pieces that are mechanically strong and durable.

Embodiments of the present invention provide a method of fabricating composite vehicle mount (i.e. track and track follower), wherein EOP (End Of Part) lines of the track and track follower are inscribed on respective moulds and after curing are transferred to the tracks and track follower to facilitate final trimming.

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Embodiments of the present invention provide a method of manufacturing composite vehicle mount (i.e. track and track follower), wherein the mould for manufacturing tracks has channels which facilitate excessive resin to be squeezed out to prevent resin richness.

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Embodiments of the present invention provide a method of fabricating composite vehicle mount (i.e. track and track follower) having lower manufacturing costs without having the need for expensive pre-impregnated composite materials or oven/autoclave curing.

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Referring now to Figure 1 an aircraft 102 is shown including a centre wing or fuselage 104, wings 106, a payload unit 108, a propulsion module 110, and tail fins 112. The propulsion module 110 may be affixed atop of the centre wing or fuselage 104 via a sliding track mounting 100, although other locations are also possible.

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Other modules attached to the aircraft 102 may also employ a sliding track mounting.

The sliding track mounting may be used to connect various modules of the aircraft 102. A sliding track mounting has the advantage(s) of easy assembly and/or self-alignment once assembled and/or allowing modules to be easily interchanged. For example, the propulsion module 110 will be automatically accurately aligned during mounting for correct and efficient operation and/or can be easily interchanged for replacement or maintenance.

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In Figures 2a and 2b, the sliding track mounting is shown including a track and a track follower assembly. The track 202 is attached (refer to Figure 5) to the upper portion of the centre wing or fuselage 104, near the front. The track follower 204 is attached (refer to Figures 3a and 3b) to the underside of the propulsion module 110.

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Generally, the location of propulsion module 110 is longitudinally balanced about the mass of the fuselage, and laterally central. In this example embodiment, the sliding track mounting 100 is predominantly external so it should be aerodynamic to avoid additional air resistance.

In operation, the track follower 204 linearly slides into the track 202. In Figure 2a, the propulsion module starts in Position A where it is not engaged to the track follower 204. In Figure 2b, the track 202 and track follower 204 are engaged, in position B. In Figure 2c, the track follower 204 is finally moved to position C where the propulsion module 110 is properly located on the centre wing or fuselage 104. A lateral aperture 200 provided on the track follower 204 cooperates with a lateral aperture (refer to Figures 4a-4c and 6a-6c) provided on the track 202 to lock the propulsion module in Position C to the centre wing or fuselage 104 using a locking pin. The track 202 extends longitudinally of the aircraft 102, such that the track follower 204 moves from the position A to the position C in a direction opposite to the normal direction of motion of the aircraft 102.

The track follower (204 in Figure 2) will now be described in more detail with respect to Figures 3a, 3b, 4, 4a, 4b and 4c. In Figure 3a and 3b, the track follower 204 is inserted and engaged to the skin 300 of the propulsion module 110.

Figures 4a, 4b, 4c shows the track follower 204 having an upper surface 402 that is curved (in transverse cross section) to mate with the outer curvature of the propulsion module skin 300. A longitudinal central member 404 supports the curved upper surface 402. The curved upper surface 402 flares away from the central member 404 at the sides 406 towards an acute tip 408. The central member 404 supports the propulsion module 110 by resting on the upper face of the track 202. An outward facing lip 406 runs longitudinally along the side of central member 404. The lip 406 slides and engages the track 202 to hold the track follower 204 in place and provide the sliding engagement. At one end of the central member 404 is a projection 410, with a lateral aperture 412 through the projection 410.

The track 202 will now be described in more detail with respect to Figures 5, 6a, 6b, and 6c. In Figure 5, the track 202 is engaged to the internal structure of the centre wing or the fuselage 104.

Figures 6a, 6b, 6c shows the track 202 including a lower surface 606, which is curved (in longitudinal cross section) to match the leading edge of the wing or fuselage 104. Downwardly extending flanges 610 at each side 608 attach to internal ribs and outwardly extending brackets 612 at each side 608 attach to internal fitting

within the centre wing or fuselage 104. The track 202 may function as an integrated structural member of the internal structure of the centre wing or fuselage 104.

A flat middle upper surface 602 extends longitudinally for the central member 404 of the track follower 204 (refer Figures 3a and 3b) to rest on. At either side of the upper surface 602, longitudinally extending slots 604 are provided to mate with the lip 406 of the track follower 204 (refer Figures 3a and 3b) to provide the sliding connection. A socket 616 is provided at one end to receive the projection 410 of the track follower 204 to provide a means of locating the track follower 204 in the position C. A lateral aperture 614 cooperates with the lateral aperture 412 of the track follower 204 to receive a locking pin, thereby locking the track follower 204 in the position C.

Referring to Figures 7a and 7b, a further embodiment is shown with a tapering track and track follower assembly. The embodiment described may not require locking apertures and a locking pin as described in the previous embodiment. However, depending on the operational requirement and loading on the assembly, locking apertures may be provided on the track 700 and the track follower 702. The track 700 is attached to the centre wing or fuselage 104 and the track follower 702 is attached to the propulsion module 110. The track 700 extends longitudinally of the aircraft 102 such that that the track follower 702 slides into the track 700 in the same direction as normal motion. The taper converges towards the direction of motion such that it exhibits a self locking/wedging effect. In the locked position a projection 704 at the trailing end of the track follower 702 sits within a socket 706 at the trailing end of the track 700. The driving force from the propulsion unit 110 is transferred to the aircraft 102 through the projection/socket and/or the wedging of the track and track follower assembly. In case a locking mechanism is provided, the wedging effect avoids or at least reduces loading on e.g. a locking pin.

Either or both of the track 202 and track follower 204 may be constructed of lightweight yet robust materials. Either or both may be constructed of a composite material. For example, the composite material may include carbon fiber and resin. Other example materials include fiberglass, Kevlar and machined aluminium.

Figure 8 is a cross sectional view of an embodiment of a composite track follower 800.

The composite track follower 800 is moulded by sequentially stacking one or more layers 801, 805, 807, 811, 813 of dry carbon fabric and balsa wood 803, 809 damped with resin in a mould (refer Figure 10). The dry carbon fabric damped with resin is flexible, and pre-cut sheets of the fabric are utilised in the described example.

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The elongate track follower 800 consists of a bottom portion 850 and a top portion 860.

In the embodiment, the lower part of the bottom portion 850 has a rectangular ridge 851 at the center. The outer layers 801 consists of one or more stacked layers 801, 805, 807, 811, 813 of the moulded carbon fabric. The body of the ridge 851 is formed by a block 803 comprising pieces of balsa wood positioned centrally along the longitudinal axis of the track follower 800. One or more layers 805 of the moulded carbon fabric are stacked on the block 803, up to the top of the bottom portion 850.

15 The inner layers of 801 and 805 abut against each other on either sides of the track follower 800.

The base of the top portion 860 consists of one or more stacked layers 807 of the moulded carbon fabric. The lower parts of the layers 807 are flush with the flat layer 805 and on either side the layers 807 are inclined. Another thin block of balsa wood 809 is located on top of the layer 807. One or more stacked layers 811 of moulded carbon fabric are positioned at an angle on either sides, the bottom edges of each layers 811 resting on the block 809 and the top edges resting on the inclined layer 807. The curved outer surface 813 consists of one or more layers of the moulded carbon fabric. The centre portion of the curved structure 813 is located on the top portion of the second block 809 of balsa wood, whilst the side portions are located on the top edges of the inclined layers 811.

Figure 9 is a cross sectional view of an embodiment of a composite track 900.

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The composite track 900 is moulded by sequentially stacking one or more layers 901, 903, 907, 909, 911, 913 of dry carbon fabric, and blocks 905 of balsa wood damped with resin on a mould (refer Figure 12).

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The track 900 consists of a bottom portion 950 and a top portion 960.

In the embodiment, the lower part of the bottom portion 950 has one or more inner layers 901 and outer layers 907 of the moulded carbon fabric. The inner layers 901 form an internal surface with two side walls, the height of the side wall being substantially smaller than the width of the internal surface. The internal surface is shaped to match a surface of the portion of the centre wing/fuselage to which the track 900 is to be mounted. The outer layers 907 of the lower portion 950 have a stepped cross section on either sides of the track 900. In addition, the bottom portion 950 has one or more intermediate layers 903 and a balsa wood plate 904, which form the lower part of the top portion 960. The top surface of the intermediate layer 903 has a pair of longitudinally parallel blocks 905 of balsa wood, each block 905 being positioned away from the centre of the track 900. The top surface of each of the block 905 of balsa wood consists of one or more c-shaped layers 909 of the moulded carbon fabric. Between the two balsa blocks 905, on the top surface of the intermediate layers 903 one or more layers 911 of the moulded carbon fabric are located, the layers 911 having a stepped cross section. In addition, the top portion 960 has one or more reinforcing layers 913 of the moulded carbon fabric, the layers 913 having a stepped cross section, on either side of the mould 900.

Figure 10 is an exploded perspective view of a mould 1000 for manufacturing the composite track follower 800 of Figure 8. The mould 1000 is designed based on a close and split concept and consists of a lower mould 1050 and an upper mould 1060.

The lower mould 1050 consists of a fixed base 1005. The top of the base 1005 has a first pair of L-shaped plates 1009 that are located along the opposite parallel edges of the base 1005. The first pair of L-shaped plates 1009 are movable relative to each other. A portion of each of first pair of L-shaped plates 1009 has a groove 1013 of a predetermined shape. In between the first pair of L-shaped plates 1009, a second pair of L-shaped plates 1007 is positioned. The top surface of the second pair of L-shaped plates 1009 are flush with the upper part of the bottom portion 850 of the track follower 800 to be fabricated. The second pair of L-shaped plates 1007 are movable relative to each other and in a direction 1011 perpendicular to the movement of the first pair of L-shaped plates 1009.

The upper mould 1060 has a mould cover 1001, the top of which is attached with one or more rails 1003. The length of the mould cover 1001 is equal to the length of the

base 1005. The top portion of the mould cover 1001 is flat, whilst the bottom portion has a predetermined shape complementary to the shape of the groove 1013 located on the first pair of L-shaped plates 1009. The groove 1013 and the shape of the top cover 1001 are designed such that they co-operate with each other so that the upper mould 1060 fits on to the lower mould 1050. This construction is useful in removing any excess resin between the various layers during moulding.

Figure 11 is a cross sectional view of the mould 1000 of Figure 10 in the direction 1011 (Figure 10). The lower mould 1050 and the upper mould 1060 are shown to be in a closed position along with the track follower 800.

In order to manufacture the track follower 800, initially, the first L-shaped plates 1007 are moved away from the centre of the mould 1000, whereby the various layers corresponding to the bottom portion 850 of the track follower 800 are assembled. Before assembling, the corners and areas corresponding to the mould joints 815 are filled with a filler, such as chopped carbon fiber strands (e.g. 12K-IM7) to ensure that there are no voids between the fabric and the mould 1000. Subsequently, one or more layers 801 of carbon fabric damped with resin are laid at the base of the lower mould 1050. Thereafter, a block 803 comprising pieces of balsa wood is laid in the recessed part of the mould 1000.

One or more flat layers 805 of carbon fabric damped with resin are again stacked on the layer 803 of balsa wood up to the top of the lower mould 1050. At this instant, the first pair of L-shaped plates 1007 are moved towards each other and towards the centre of the mould 1000, whereby the various layers of the top portion 860 of the track follower 800 are assembled.

One or more flat layers of dry carbon fabric 807 damped with resin are laid on top of the flat layer 805 such that the center portion of the layer 807 is flush with the flat layer 805, whilst the two sides of the layer 807 are flush with the inclined edge of the first L-shaped plates 1007.

A thin second block 809 of balsa wood is laid on top of the flat portion of the layer 807. On top of the second balsa layer 807, one or more layers of dry carbon fabric 811 damped with resin are laid at an angle, on either sides, the bottom edges of each

layer 811 rest on the second block 809 of balsa wood, whilst the top edges rest on the inclined layer 807 at various points.

Subsequently, one or more layers of carbon fabric 813 damped with resin are laid so as to negotiate a curve, the centre portion of the curved structure touching the top portion of the second block 809 of balsa wood and the side portions resting on the layers 807 and 811 at various points.

After this, the lower mould 1050 and the upper mould 1060 are closed and fastened together so as to remove any excess resin through channels provided in the lower 1050 and upper 1060 moulds.

Curing of the closed mould is done either at ambient temperature for 23 hours or below 80°C for 6 hours. Such a curing process is advantageous in that there is no room for thermal expansion and there is no distortion owing to matching tolerance between mating parts.

After curing, the two pairs of L-Shaped 1007 and 1009 are opened out and demoulded to obtain the moulded track follower 800.

The moulded track follower 800 is then trimmed to smoothen the edges.

In an embodiment, the edges of the moulded track follower may be smoothened to a desired end of part (EOP) line inscribed in the mould during the moulding process.

Figure 12 is an exploded perspective view of a mould 1200 for manufacturing the track 900 of Figure 9. The mould 1200 is designed based on close and split concept and consists of a lower mould 1250 and an upper mould 1260.

The lower mould 1250 consists of a fixed base 1213. The top of the base 1213 has a pair of L-shaped plates 1207 located along the opposite parallel sides of the base 1213. A block 1209 movable in the direction of 1257 is provided on a side adjacent to the sides having the L-shaped plates 1207. Each of the pair of L-shaped plates 1207 are movable relative to each other.

The block 1209 is provided to form void portion 1251 of the track 900 to be moulded. Two balsa blocks 905 are seen located on either sides, each block 905 being adjacent to one of the L-shaped plate 1207. The two balsa blocks 905 are embedded during the mould layering to be located inside the voids 1253 in the track 900 to be formed. A balsa wood plate 904 is provided for incorporation into the track to be moulded.

The upper mould 1260 has a mould cover 1201, a first plate 1203 and a second plate 1205. The top portion of the mould cover 1201 is flat, whilst the bottom portion is recessed to accommodate the first plate 1203. The top surface of the first plate 1203 is flat, whilst the bottom surface has projections that cooperate with recesses present on the top surface of the second plate 1205.

The mould cover 1201, the first plate 1203, and the second plate 1205 are so designed to co-operate with each other so that the top mould 1260 fits on to the bottom mould 1250. This construction is useful to remove any excess resin between the various layers during moulding.

Figure 13 is a cross sectional view of the mould 1200 of Figure 12 in a direction 1211 (Figure 12). The lower mould 1250 and the upper mould 1260 are shown to be in a closed position along with the track 900.

In order to manufacture the track follower 900, initially, the first L-shaped plates 1207 are moved away from the centre of the mould 1200, whereby the various layers corresponding to the bottom portion 950 of the track follower 900 are laid. Before assembly, the corners and areas corresponding to the mould joints 915 are filled with filler, such as chopped carbon fiber strands (e.g. 12K-IM7) to ensure that there are no voids between the fabric. Subsequently, one or more inner layers 901 of carbon fabric damped with resin are laid at the base of the lower mould 1250.

On top of the layers 901, one or more intermediate layers 903 of carbon fabric damped with resin are laid. On top of this intermediate layer 903, a pair of longitudinally parallel blocks 905 and plate 904 of balsa wood are positioned, each blocks 905 being positioned away from the centre of the track 900. After this, one or more c-shaped layers 909 of carbon fabric are laid on each of the balsa wood blocks 905. Subsequently, one or more layers 911 of carbon fabric having a stepped cross

section are laid in between the two balsa wood blocks 905 and the balsa wood plate 904.

On top of the layers 911, between the balsa wood blocks 905, the balsa wood plate 904, the second plate 1205 and first plate 1203 are laid above the center of the lower mould 1250.

One or more reinforcing layers 913 and outer layers 907 having a stepped construction are laid on either side of the lower mould 1250.

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At this instant, the first pair of L-shaped plates 1207 are moved towards each other and towards the centre of the mould 1200.

After this, the lower mould 1250 and the upper mould 1260 are closed and fastened together so as to remove any excess resin through channels provided in the lower 1250 and upper 1260 moulds.

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Curing of the closed mould is done either at ambient temperature for 23 hours or below 80°C for 6 hours. Such a curing process is advantageous in that there is no room for thermal expansion and there is no distortion owing to matching tolerance between mating parts.

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After curing, the two pairs of L-Shaped 1207 and 1209 are opened out and demoulded to obtain the moulded track 900.

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The moulded track 900 is then trimmed to smoothen the edges.

In an embodiment, the edges of the moulded track 900 may be smoothened to a desired end of part (EOP) line lines inscribed in the mould during the moulding process.

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Figure 14 shows a flow chart 1400 illustrating a method of manufacturing a composite vehicle mount in an example embodiment. At step 1402, a mould structure corresponding to the shape of the vehicle mount is provided. At step 1404, corners and areas corresponding to the mould joints are filled with fillers. At step 1406, one or more layers of a composite material are damped with resin. At step 1408, the damped layers of composite material are stacked on the mould structure, including

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positioning one or more layers of balsa wood in between the damped layers of composite material. At step 1410, the stacked layers are cured to form the composite vehicle mount. At step 1412, the mould structure is removed, and at step 1414, the composite vehicle mount is trimmed and smoothed.

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Although, carbon fiber is used as a composite for making the above track and track follower, other materials, such as fiberglass, Kevlar and machined aluminium may also be utilised.

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It will be appreciated that the invention may also be applicable to modular devices for vehicles generally where there is a need for accurate alignment, and/or fast assembly. One skilled in the art will also appreciate other applications are appropriate.

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It will be appreciated by a person skilled in the art that numerous variations and/or modifications may be made to the present invention as shown in the specific embodiments without departing from the spirit or scope of the invention as broadly described. The present embodiments are, therefore, to be considered in all respects to be illustrative and not restrictive.

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CLAIMS

1. A method of manufacturing a composite vehicle mount, said method comprising the steps of:
 - 5 providing a mould structure corresponding to the shape of the vehicle mount; - filling corners and areas corresponding to the mould joints with fillers; - damping one or more layers of a composite material with resin; - stacking the damped layers of composite material on the mould structure, including positioning one or more layers of balsa wood in between the damped layers
10 of composite material; - curing the stacked layers to form the composite vehicle mount; - removing the mould structure; and
trimming and smoothening the composite vehicle mount.
- 15 2. The method of claim 1, wherein before the step of curing, the method further comprises:
 - closing and fastening the mould structure with a mould cover; and
removing the excess resin between the stacked layers.
- 20 3. The method of claim 1 or 2, wherein the excess resin between the stacked layers is removed through channels provided in the mould structure.
4. The method of any one of the preceding claims, wherein the filler comprises chopped carbon fiber strands.
- 25 5. The method of any one of the preceding claims, wherein said composite material comprises one or more of a group consisting of carbon fiber, fiberglass, Kevlar and machined aluminium.
- 30 6. The method of any one of the preceding claims, wherein an end of line is inscribed on the mould structure and transferred onto the formed composite vehicle mount.
7. The method of claim 5, wherein after curing, edges of the composite vehicle
35 mount are smoothened to a desired end of part (EOP) line inscribed on the mould structure and transferred onto the formed composite vehicle mount.

8. The method of any one of the preceding claims, wherein the curing is performed at ambient temperature for 23 hours or below 80°C for 6 hours.

5 9. The method of any one of the preceding claims, wherein the composite vehicle mount comprises a track or a track follower of a unmanned aerial vehicle (UAV) or a modular aircraft.