

CLAIMS

1. Method for inspecting and/or manipulating a beam (11) at a lower side of a roof or deck (10), wherein the beam (11) comprises a strip (13) which has a first surface (14) facing said lower side and spaced apart therefrom, and a second surface (15) facing away from the first surface (14), the method comprising:
- providing an unmanned aerial vehicle, UAV, (20), the UAV comprising:
 - a body (21), comprising an abutment element (23) having a top surface (24) adapted for abutting the second surface (15) of the strip (13);
 - 10 a number of rotors (22) for exerting a propulsion force on the UAV (20) in an upward direction, wherein the rotors (22) are supported by the body (21) and arranged below the top surface (24);
 - a first arm (30), pivotably connected to the body (21), the first arm (30) having an end portion (32) for contacting the first surface (14), wherein the first arm (30) is movable relative to the body (21) between a first position in which, when seen in projection onto a plane parallel to the top surface (24), the end portion (32) is spaced apart from the top surface (24), and a second position in which the end portion (32) of the arm (30) is arranged above the top surface (24); and
 - 15 an inspection and/or manipulation tool (55);
- the method further comprising the steps of:
- 20 - while the first arm (30) is in the first position, controlling the rotors to exert a propulsion force on the UAV (20) for flying the UAV towards the beam (11) such that the top surface (24) approaches the second surface (15) of the strip (13);
 - when the top surface (24) of the abutment element (23) contacts the second surface (15) of the strip (13), moving the first arm (30) from the first position to the second position such that
 - 25 the end portion (32) of the first arm (30) is moved to a position vertically above the first surface (14) of the strip (13), and preferably such that the first surface (14) is arranged between the body (21) and the end portion (32) of the first arm (30);
 - controlling the rotors (22) to reduce the upwardly directed propulsion force until the UAV (20) hangs from the beam (11) with the end portion (32) of the arm (30) in contact with and
 - 30 supported by the first surface (14) of the strip (13); and
 - inspecting and/or manipulating the beam (11), using the inspection and/or manipulation tool (55), while the UAV (20) hangs from the beam.
2. Method according to claim 1, wherein, when the UAV (20) hangs from the beam (11), the top surface (24) is spaced apart from the second surface (15).
3. Method according to claim 1 or 2, wherein the UAV (20) further comprises:
- a second arm (40), pivotably connected to the body (21), the second arm (40) having an end portion (42) for contacting the first surface (14), wherein the second arm (40) is movable

relative to the body (21) between a first position in which, when seen in projection onto a plane parallel to the top surface (24), the end portion (42) is spaced apart from the top surface (24), and a second position in which the end portion (42) of the second arm (40) is arranged above the top surface (24);

5 the method further comprising, when the top surface (24) of the abutment element (23) contacts the second surface (15) of the strip (13):

- moving the second arm (40) from the first position to the second position such that the end portion (42) of the second arm (40) is moved to a position vertically above the first surface (14) of the strip (13), and preferably such that the first surface is arranged between the body (21)
10 and the end portion (42) of the second arm (40),

 and wherein, when the rotors (22) are controlled to reduce the upwardly directed propulsion force until the UAV (20) is in a hanging position, wherein the UAV is supported on the beam by the end portions (32, 42) of the first and second arms (30, 40) which contact the first surface (14) of the strip (13).

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4. Method according to any one of the preceding claims, further comprising, when the UAV (120) hangs from the beam, moving the UAV (120) along the beam (11) using a propulsion mechanism (158; 258; 358; 458; 558) of the UAV while the propulsion mechanism is in contact with the beam (11), preferably while the rotors (122) are switched off.

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5. Method according to claim 4, wherein the propulsion mechanism (158; 258; 358; 458; 558) comprises one or more rotatable wheels (160; 260; 360; 460; 560), wherein said wheels: are comprised in the end portions (132, 142) of the first arm (130) and/or second arm (140); and/or are part of the top surface (325) of the abutment element (323).

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6. The method according to claim 5, wherein at least one of the wheels (160; 260; 360; 460; 560) is driven, preferably by an electromotor of the UAV (20).

7. The method according to any one of the preceding claims, wherein the UAV comprises a
30 manipulation tool in the form of cleaning equipment for cleaning a portion of the beam, and comprises an inspection tool for inspection a portion of the beam, the method comprising, when the UAV is in a hanging position in which the UAV is supported on the beam:

 operating the cleaning equipment to clean a portion of the beam;
 positioning the inspection tool at the cleaned location of the beam and inspecting said cleaned
35 location using the inspection tool.

8. Unmanned aerial vehicle, UAV, (20) for inspecting and/or manipulating a beam (11) at a lower side of a roof or deck (10), wherein the beam comprises a strip (13) which has a first surface (14) facing said lower side and spaced apart therefrom, and a second surface (15) facing away from

the first surface (14), the beam further comprising an upright portion (12) which extends upwards from the first surface (14) and wherein the first surface extends from either side of the upright portion, the UAV comprising:

5 a body (21) comprising an abutment element (23) which has a top surface (24) adapted for abutting the second surface (15) of the strip (13);

a number of rotors (22) supported by the body (21), the rotors being arranged below the top surface (24) and adapted for exerting a propulsion force on the UAV in an upward direction;

10 a first arm (30), pivotably connected to the body (21), the first arm (30) having an end portion (32) for contacting the first surface (14), the first arm (30) being movable relative to the body (21) between a first position in which, when seen in projection onto a plane parallel to the top surface (24), the end portion (32) is spaced apart from the top surface (24), and a second position in which the end portion (32) of the first arm (30) is arranged above the top surface (24);

15 a second arm (40), pivotably connected to the body (21), the second arm (40) having an end portion (42) for contacting the first surface (14), the second arm (40) being movable relative to the body (21) between a first position in which, when seen in projection onto the plane parallel to the top surface (24), the end portion is spaced apart from the top surface (24), and a second position in which the end portion (42) of the second arm (40) is arranged above the top surface (24); and

20 an inspection and/or manipulation tool (55; 155a, 155b) for inspecting and/or manipulating the beam or a portion thereof;

wherein the end portions (32, 42) of the first and second arm (30, 40) each comprise a contact surface (33, 43) adapted for contacting the first surface (14), each contact surface, when its corresponding arm is in the second position, facing towards the body (21) of the UAV, wherein in their respective second position the first arm is capable of resting on a portion of the upper surface on one side of the upright portion of the beam, and the second arm is capable of resting on a portion of the upper surface on an opposite side of the upright portion of the beam

9. The UAV according to claim 8, wherein the contact surfaces are configured to be arranged spaced apart from each other on either side of the upright portion of the beam when the arms are in the second position.

10. The UAV according to claim 8 or 9, wherein the first and second arm are arranged such that, when they are moved from the first position to the second position, a lateral distance between the contact surfaces of the first and second are decreases continuously during said movement.

35 11. The UAV (20) according to any one of claims 8-10, wherein the arms (30, 40), when in their first positions, are completely arranged below a plane (P) through the top surface (24), the plane (P) being parallel to a plane (R) in which the rotors extend.

12. The UAV (20) according to any one of claims 8-11, wherein the arms (30, 40), when in their first positions, are arranged completely between a plane (R) in which the rotors extend and a plane (P) parallel thereto through the top surface (24).
- 5 13. The UAV (20) according to any one of claims 8-12, wherein, when the arms (30, 40) are in their first positions, all parts of the UAV (20) are completely arranged at a side of the top surface (24) which faces towards the body (21).
- 10 14. The UAV (20) according to any one of claims 8-13, wherein the UAV (20) is adapted for approaching the beam (11) with the arms (30, 40) in their first positions, and for hanging from the beam (11) in a hanging position with the arms (30, 40) in their second positions, in which the UAV (20) is supported by the end portions (32, 42) of the arms (30, 40), with said end portions (32, 42) contacting the first surface (14) of the strip (13).
- 15 15. The UAV (120) according to any one of claims 8-14, wherein the inspection and/or manipulation tool comprises one or more sensors (155) adapted for measuring a thickness of the beam, preferably wherein said one or more sensors are arranged on the first arm (130) and/or second arm (140), more preferably wherein the one or more sensor (155) are adapted for determining a thickness of a portion (12) of the beam (11) that extends substantially normal to the first surface (14) of the strip.
- 20 16. The UAV (20) according to any one of claims 8-15, wherein the inspection and/or manipulation tool (55) comprises cleaning equipment for cleaning a portion of the beam, preferably wherein the cleaning equipment comprises a steel brush.
- 25 17. The UAV (120) according to any one of claims 8-16, wherein the UAV (120) further comprises a propulsion mechanism (158; 258; 358; 458; 558), adapted for moving the UAV (120) along the beam (11) while making contact with the beam (11).
- 30 18. The UAV (120) according to claim 17, wherein the propulsion mechanism (158; 258; 358; 458) comprises rotatable wheels (160; 260; 360; 460; 560), wherein each wheel is comprised in one of the first arm (130), the second arm (140), and the abutment element.
- 35 19. The UAV (120) according to claim 17 or 18, further comprising a motor for driving rotation of one or more of said wheels (160; 260; 360; 460; 560).
20. The UAV (220) according to any one of claims 8-19, wherein the first arm (230) and/or the second arm (240) is further provided with an alignment device (265, 266) adapted for contacting

a portion (12) of the beam (11) between the strip (13) and the lower side of the deck or roof (10) when the arms (230, 240) are in the second positions.

21. The UAV (220) according to any one of claims 8-20, wherein both the first arm (230) and
5 second arm (240) are provided with an alignment device (265, 266) for contacting oppositely facing surfaces of a portion (12) of the beam (11) between the strip (13) and the lower side of the deck or roof (10) when the arms (230, 240) are in the second positions.

22. The UAV (20) according to any one of claims 8-21, wherein the first arm (30) and the second
10 arm (40) are arranged opposite from each other, such that when the arms are moved from the first to the second positions, the end portions of the arms approach each other.

23. The UAV (20) according to any one of claims 8-22, wherein the inspection and/or manipulation
15 tool (55; 155a,155b) is arranged on the first and/or second arm, or is located on the body of the UAV or on a separate arm of the UAV so that the tool can be moved towards and away from a beam when the UAV hangs from the beam.

24. The UAV (20) according to any one of claims 8-23, wherein a location of pivotable connections
20 between the body (21) and the first arm (30) and/or second arm (40) is mechanically adjustable, preferably in such a manner that a distance between the pivotable connections of the first and second arms is adjustable.

25. The UAV (20) according to any one of claims 8-24, wherein the first arm (30) and/or the
25 second arm (40) have a nonlinear shape, preferably a sickle-shape, a hook-shape or an L-shape.

26. The UAV (120) according to any one of claims 8-25, further comprising a third arm (570) and a fourth arm (580).

27. The UAV (20) according to any one of claims 8-26, wherein the inspection and/or
30 manipulation tool (55; 155a,155b) is arranged on an end portion of one of the arms (30, 40, 50), or preferably on a separate, non-supporting arm (50).

28. The UAV according to any one of claims 8-27, wherein the first and second arm are each
35 provided with one or more wheels at their respective end portions, wherein the first and second arm are configured such that one or more axes of rotation of the wheels of the first arm substantially intersect one or more wheels of the second arm when the arms are in the second position, and/or one or more axes of rotation of the wheels of the second arm substantially intersect one or more wheels of the first arm when the arms are in the second position.