ALL WHEEL STEERING SYSTEM FOR AN IMPLEMENT CARRIER, IMPLEMENT CARRIER AND METHOD

The invention concerns an all-wheel steering system for an implement carrier, where the steering system is arranged to optimize the steering geometry relative to an implement mounted to the implement carrier.

Background for the invention

On a traditional tractor with steerable front wheels and fixed rear wheels, the tractor will have a vehicle turning centre (VTC) which coincide with a centre axis of the fixed rear wheels. The vehicle turning centre may move along this centre axis from an infinite distance from the tractor when the front wheels begin to turn, and to a close distance, typically 6-7 meters from the rear wheels, when the front wheels have their maximum steering angle.

An implement connected to a tractor has an implement turning line (ITL) which is transversely oriented trough a working centre of the implement. For example, for a disc mover, the implement turning line constitutes a line extending horizontally through the rotational centres of a plurality of discs mounted to a cutter bar on the disc mover. For a sprayer, the implement turning line coincides with a horizontal line extending through a plurality of nozzles mounted to a sprayer boom.

On a traditional tractor, a mounted implement is connected to the tractor via a front linkage or a rear linkage, and the implement turning line is therefore behind or in front of the vehicle turning centre. When driving along a straight track line, a centre point of the implement, in the following referred to as an implement working centre (IWC), coincides with a longitudinal centre line for the tractor, when the implement is mounted in centre of the tractor. If a 3-meter long implement is connected transversely to the tractor, and the tractor is driven along straight and parallel tracks with a centre distance of 3 meters, the working width of the implement will be utilized 100 %, as there will be no overlap. As soon as the tractor turns, the implement working centre will shift sideways relative to the track line. This will result in a reduced effective working width and too much overlap on one side and too little overlap on the other side. The effective working width is reduced, and the overlap is increased as the turning angle increases and the longitudinal distance from the vehicle turning centre to the implement working centre increase.

Too much overlap may result in overconsumption of energy, pesticides and fertilizer and uneven yield quality. Too little overlap may result in uneven yield quality and reduced yield.

Example:

A 3-meter-wide front mover is connected to the front linkage of a traditional tractor. The implement turning line is 7 meters in front of the vehicle turning centre, which coincide with the centre axis of the rear wheels. When driving along straight track lines, the centre point of the front mover will coincide with the centre axis of the tractor along the track. This will give zero overlap, and the actual working width is equal to the front mover's working width. When the tractor drives in a left-hand curve, the centre of the mover will shift to the right-hand side of the curved track line. The sharper curve, the less effective the working width and the more incorrect the overlap. On the outside of the track line, the overlap will be too large. On the inside of the track line, the overlap will be too small. Too large overlap may result in overconsumption of energy, pesticides and fertilizer and uneven yield quality. Too little overlap may result in uneven and reduced yield quality.

A correct overlap in curves is possible if the tractor is positioned so that the implement is shifted sideways from the track line so that the side edge of the implement follows the side edge of the processed working area. However, the actual working width will still be reduced, and the tractor wheels may drive on uncut grass or unprocessed ground, which is unfortunate.

In operations that require high precision, such as grass mowing or spraying around obstacles or on complex areas, it is known to compensate for the long longitudinal distance between the implement turning line and the vehicle turning centre by moving or turning the implement sidewise in curves. This does however only reduce the problem, not solve it.

It is also known to position the implement in the middle of the vehicle, between the front axle and the rear axle on an all-wheel steering implement carrier, where the front wheels and the rear wheels have a symmetrical steering angle. But if the implement carrier is equipped with different kind of implement, i.e. if switching between different types of implements, there will always be some errors.

Patent document US5996722 discloses a tractor with a front wheel axle and a rear wheel axle. The tractor carries an implement by a linkage or tows a trailer. The front wheels are steered normally by a steering wheel. The rear wheels can be held in fixed alignment, or they can be steered in various selectable modes, being slaved to the front wheels. In one mode, they are turned in the opposite direction to the front wheels, to give a very tight turning circle. In another mode, they turn with the front wheels but to a smaller degree, governed by the tractor wheelbase and the distance of the implement behind the tractor, to keep lateral forces on the implement to a minimum. There can be automatic changeover between modes of steering. The effect of the system disclosed in US5996722 is that the lateral forces on a mounted implement are reduced when driving in curves, and that an increased working width of the implement may also be available in curves.

The invention has for its object to remedy or to reduce at least one of the drawbacks of the prior art, or at least provide a useful alternative to prior art.

The object is achieved through features, which are specified in the description below and in the claims that follow.

General description of the invention

The invention is defined by the independent patent claims. The dependent claims define advantageous embodiments of the invention.

In a first aspect the invention relates more particularly to an all-wheel steering system (AWS) for an implement carrier, the implement carrier comprising at least one front wheel and at least one rear wheel, all wheels being individually steerable, and a linkage for carrying an implement, the AWS comprising:

- a control unit (CPU) and steering means arranged to steer each wheel in response to a control signal from the control unit so that the rotational centre axes for each of the wheels meet in a vehicle turning centre (VTC) for the implement carrier along an implement turning line (ITL) extending perpendicularly to a working direction of the implement and through a working centre of the implement (IWC), so that vehicle turning centre (VTC) coincides with the turning centre of the implement working centre (IWC) when the implement carrier turns. The implement turning line, by means of the control unit, is adapted to be positioned in front of the rear wheels or behind the front wheels, including a position between the front wheels and the rear wheels.

By an implement carrier is herein understood a vehicle arranged to carry an implement on-road or off-road. The implement carrier may comprise at least three wheels. The implement carrier may comprise four or more wheels. Two wheels may be arranged as a pair. Said pair of wheels may be arranged side by side on a virtual wheel axle.

By steering means is herein understood any means arranged to turn a wheel about a turning axis. Said means may for instance be, but not limited to, a rotatable actuator or a linear actuator. The actuator may be operated by a fluid or by electricity.

By implement turning line is herein understood a line extending perpendicularly to a working direction of the implement and trough a working centre of the implement (IWC), the working centre being positioned in centre where the working width of the implement is defined. Examples:

For a disc mover, the implement turning line coincides with a horizontal line extending through the rotational centres of a plurality of discs mounted to a cutter bar on the disc mover. The implement turning/working centre may be in the centre of the disc mower, along the implement turning line.

For a sprayer, the implement turning line coincides with a horizontal line extending through plurality of nozzles mounted to a sprayer boom. The implement working centre may be in the centre of the sprayer, along the implement turning line.

For a centrifugal fertilizer spreader, the implement turning line coincides with a horizontal line extending through the widest portion of the fertilizer. The maximum spread width is typically several meters behind the spreader. Consequently, the implement turning line will also be several meters behind the spreader.

For implements where the working body is arranged perpendicularly to the driving/working direction, such as movers, sprayers and spreaders, the working width will be the same when the implement is turning left and right. If the vehicle turning centre coincides with the implement turning line, the working width may be constant regardless of if the tool carrier is driving in a straight line or in a curve. If the vehicle turning centre does not coincide with the implement turning line, the working width will be reduced when driving in curves and the reduction will be equal for a left hand-side curve and a right hand-side curve.

For an implement with a diagonal working body, for instance a diagonal snow plough and a diagonal sweeper, the working width will be reduced when turning to the right and increase when turning to the left, or opposite, depending on to which side the implement is angled. An implement with an angled working body may therefore not have a clearly defined implement working centre, which is in contrast to non-angled implements.

The implement carrier can turn around one vehicle turning centre only. If more than one implement is connected to the implement carrier, a leading implement turning line must be set, either manually or automatically.

A so-called butterfly mover comprises a front mower and two rear movers, the front mover having a first implement turning line and the rear movers having a second implement turning line. For such a configuration the leading implement turning line to be used by the system, may be set in the middle between the front mower and two rear movers.

The system may also shift the position of the leading turning line during operation. If for instance one or two of the three movers is/are lifted from the ground, the system may automatically use the implement turning line for the last operating mover as the leading implement turning line.

By track line is herein understood a defined line which a tractor or an implement follows along its working direction. Two or more track lines may be positioned in parallel. The track line may be pre-set, for instance via GPS auto track system. The track line may be set by the implement carrier during driving. The track line may be a straight A-B line. The track line may be a curved line. The track line may comprise segments with different geometries. When a centre distance between two adjacent track lines is equal to the working width of an implement, there will be no overlap. When the centre distance is larger than the working width, a negative overlap will occur. When the centre distance is smaller than the working width, a positive overlap will occur. For agricultural operations, zero overlap is desirable. Zero overlap gives the best utilization of the inputs as for instance seed, fertilizer and pesticides, the minimum use of energy, and even yield quality. Negative overlap (too little overlap) may result in uneven yield quality and reduced yield quality. Positive overlap (too large overlap) may result in overconsumption of for example energy, pesticides and fertilizer and uneven yield quality.

By vehicle track line is herein understood a track line in which a vehicle reference point of the vehicle follows/coincides with during driving.

By implement track line is herein understood as a track line in which an implement reference point of the implement is arranged to coincide with during driving. The defined reference point may be a centre point of the implement, implement working centre (IWC), on the implement turning line.

The effect of the implement turning line being positioned in front of the rear wheels or behind the front wheels including a position between the front wheels and the rear wheels, is that the implement carrier may turn around the implement turning line, including when the implement is mounted in front of the front wheels, behind the rear wheels, between the front wheels and the rear wheels and next to the wheels. Consequently, zero overlap may be achieved with any kind of implement and operation.

The all-wheel steering system may be arranged to position the implement carrier so that the implement turning line is perpendicular to an implement track line, the implement carrier following the track line or setting the track line, whereby an implement can have the same effective working width in curves as along a straight line.

When using a front mover on a traditional front wheel steered tractor, the effective working width may be reduced as much as 50 % or more in sharp curves. When the implement is positioned so that the implement turning line is perpendicular to an implement track line, the effective working width may be 100 % even in sharp curves.

An implement working centre may coincide with the implement track line.

By implement working centre is herein understood a centre of the implement, the implement working centre being positioned along the implement turning line. The implement turning line may also be regarded as a radius extending from the implement working centre and to the turning centre of the implement. When the implement carrier / vehicle turns, the all-wheel steering system according to the invention enables the vehicle and the implement (IWC) to rotate around a common turning centre.

The implement working centre for an in-line symmetrical implement, for instance a front mower and a sprayer, is typically aligned with a longitudinal centre axis of the implement carrier. If the implement is arranged for off-set use, for instance an arm mover, the implement working centre will be off-set of the implement carrier's centre line. The effect of the implement working centre coinciding with the implement track line, is that zero overlap may be achieved both in curves and along a straight line, since the implement carrier follows the position of the implement. Depending on the position of the implement, the implement carrier may have large lateral resultant movements.

The position of the implement turning line and/or the implement working centre relative to a vehicle reference point may be set manually in the control system by an operator.

For the control system being able to calculate the correct turning angles of the wheels, the control system needs to know the position of the implement turning line and/or implement working centre and the wheels relative to a fixed vehicle reference point on the implement carrier. The position of the wheels is constant, whilst the position of the implement turning line and/or implement working centre may change with different implements and where the implements are mounted to the implement carrier.

The actual distance to be set may for instance be a longitudinal distance from the implement turning line and to an implement linkage arm connection point. The distance may also include an offset from the longitudinal centre axis of the implement carrier to the implement working centre.

The geometrical values, e.g. the dimensions and working centre, for a specific implement may be stored in the control system. This makes it possible to enter the required data for the specific implement only once and retrieve the setting when connecting the implement at a later stage.

The position of the implement turning line and/or the implement working centre relative to the vehicle reference point may be set automatically as the control unit receives an electronic signal from the implement.

An advantage with this feature, is a fast and precise set up of the system compared to manual input, and the required values for the implements may be stored in the control system.

The electronic signal may be transferred via ISOBUS. ISOBUS is an international communication protocol that sets the standard for agriculture electronics. This mean that any implement having ISOBUS, may automatically transfer the geometrical required values for a correct set-up of the implement turning line and vehicle turning centre, when the implement is connected to the tool carrier.

The electronic signal may be transferred via RFID. RFID enables the system to retrieve identify an implement which do not have ISOBUS, and retrieve possible settings stored in the control system.

The steering system may be remotely operated. An effect with the remote operation is that an implement carrier with the all-wheel steering may be remotely operated in real-time.

The steering system may be autonomously operated. An effect with the autonomous operation is that an implement carrier with the all-wheel steering may work autonomously when the conditions are at the best, and not only when an operator is available.

In a second aspect the invention relates more particularly to an implement carrier comprising an all-wheel steering system according to the first aspect of the invention, the implement carrier comprising a pair of individually steerable front wheels (FL, FR), a pair of individually steerable rear wheels (RL, RR) and a linkage for carrying an implement (5).

The linkage may be positioned between the front wheels and the rear wheels. An effect of this position is improved weight distribution and less soil compaction since no counterweight is needed to keep the implement carrier in balance.

The turning angle of each wheel may be at least 300 degrees. An effect of said turning angle is that the implement carrier may drive sideways, both when connecting to an implement, and in operation.

The implement carrier may be arranged for autonomous operation. An effect of the autonomous feature is that the implement carrier may work on its own day and night. The autonomous feature may comprise GPS, radar and other sensors required to ensure safe and precise operation. The autonomous feature enables operations to be executed with precision, and under the most favourable weather conditions, minimizing usage of seeds, fertilizers, and pesticides.

In a third aspect, the invention relates to a method for using the implement carrier , where the method comprises the step of:
- connecting an implement to the implement carrier, said implement having a an implement turning line (ITL) being positioned perpendicularly to a working direction for the implement and trough a working centre of the implement;
- set a position of the implement turning line (ITL) and/or implement working centre (IWC) relative to a vehicle reference point (VRP);
- aligning the vehicle turning centre (VTC) of the implement carrier with the turning centre of the implement working centre along the implement turning line (ITL) when the im-

plement carrier turns.

In the following are described examples of preferred embodiments illustrated in the accompanying drawings, wherein:

Fig. 1	shows in perspective an implement carrier comprising an all-wheel steering system and carrying a sprayer;
Fig. 2	shows figure 1 from above;
Fig. 3	shows a further details from the all-wheel steering system from Fig. 1 seen from above;
Fig. 4	shows the implement carrier carrying a lawn mower;
Fig. 5	shows a principle drawing the all-wheel steering in combination with a centre mounted lawn mower;
Fig. 6	shows a principle drawing the all-wheel steering in combination with a front mounted lawn mower.
Fig. 7	shows an operational difference between a conventional tractor and an all-wheel steered implement carrier when working with a front mounted implement
Fig. 8	shows a principle drawing of a three-wheeled implement carrier comprising the all-wheel steering system;
Fig. 9	shows a principle drawing of a four-wheeled implement carrier comprising the all- wheel steering system;
Fig. 10	shows a principle drawing of a six-wheeled implement carrier comprising the all- wheel steering system;
Fig. 11	shows a schematic drawing of the all-wheel steering system; and

Fig. 12 shows an exemplary flow diagram for controlling the all-wheel steering system.

Figures 1 and 2 show an implement carrier 1 comprising a pair of front wheels FL, FR and a pair of rear wheels RL, RR. All wheels FL, FR, RL, RR being individually steerable, as will be discussed in more detail below. The implement carrier 1 further comprises a linkage 10 carrying an implement 5, here shown as a sprayer 5a. The sprayer 5a being mid-mounted, between the front wheels FL, FR and the rear wheels RL, RR. The sprayer 5a comprises a boom 51 provided with multiple nozzles 52 arranged underneath the boom 51. A horizontal line extending centrally through the nozzles 52 defines an implement turning line ITL for the implement carrier 1.

The boom 51 and the implement turning line ITL are arranged perpendicularly to a direction of work A of the sprayer 5a. When the boom 51 is perpendicular to the direction of work A as illustrated, the working width WW1 of the boom 51 is at its largest, and the distribution of a liquid, for instance e pesticide, is 100 per cent correct as no overlap of liquid between the nozzles 52 will occur. If the boom 51 is slanted (not shown) relative to the direction of work A the relative distance between the nozzles 52 will be reduced, and an overlap of liquid between the nozzles 52 will occur, causing too much liquid on the plants.

As shown in figure 2, the all-wheel steering AWS allows a rotational centre axis FLX, FRX, RLX, RRX for each of the wheels FL, FR, RL, RR to meet in a common vehicle turning centre VTC on the implement turning line ITL for the sprayer 5a so that also the turning centre of the implement (IWC, as shown e.g. in Fig. 3) meet ~~meeting~~ in the vehicle turning centre This enables the sprayer boom 51 to always extend in a direction perpendicular to the direction of work A, regardless of the implement carrier drives along a straight line or in a curve. This effect is illustrated in figures 5 and 6.

Figure 3 shows the four-wheel implement carrier 1 from figure 2 without the implement for clarity, where the implement turning line ITL and the implement working centre IWC, in the shown embodiment, are located midway between an imaginary front axle ~~FA~~ and an imaginary rear axle ~~RA~~ having a wheelbase WB. The front wheels FR, FL form the imaginary front axle FA and the rear wheels FR, FL form the rear axle RA. The linkage 10 is positioned at a distance FI from the front axle FA and a distance IW from the implement turning line ITL. When the implement working centre IWC is midway between the front axle and the rear axle as illustrated, the inner wheels FL, RL will have the same (absolute) steering angle FIo, RLo, and the outer wheels RF, RR will have the same steering angle FRo, RRo, when the implement carrier / vehicle is driving in a curve as indicated in the figure.

Figure 4 shows an exemplary implement 5, here in the form of a lawn mower 5b, connected to the implement carrier 1. The lawn mower 5b is connected to the implement carrier 1 via the linkage 10 and is positioned between the front wheels FL, FR and the rear wheels RL, RR, similarly to the sprayer 5a in figures 1 and 2.

Figure 5 shows a principle top view of the implement carrier 1 and the lawn mower 5b shown in figure 4 in use. The lawn mower 5b comprises multiple discs 59 arranged to cut grass. The discs 59 are arranged in a line and form an implement turning line ITL for the implement carrier 1b as explained above. The implement turning line ITL coincide with a line extending through the rotational centres of the discs 59, as for the nozzles 52 in figure 2. The discs 59 and the implement turning line ITL are arranged perpendicularly to a direction of work A of the lawn mower 5b.

The implement carrier 1 may follow implement ~~trac~~ track lines IRCL, comprising curved sections and straight sections. The implement ~~trac~~ track lines IRCL may be set by an operator via a control system for the implement carrier 1. The implement carrier 1 may follow the ~~trac~~ track lines IRCL by use of GPS signals. The implement carrier 1 may create the implement ~~trac~~ track lines IRCL of the implement carrier 1, for instance if the implement carrier 1 is manually steered via a control unit. The all-wheel steering system AWS enables the implement/vehicle turning centre VTC to always align with the implement turning line ITL. As a result, the actual working width WW2 will always be the same as the implement 5 working width WW1, regardless of if the implement carrier 1 is driving straight forward or in a curve.

Figure 6 shows the lawn mower 5b positioned in front of the implement carrier 1. Consequently, the implement turning line ITL is positioned in front of the front wheels FL, FR. As for the previous example, the position of the implement 5 and the implement turning line ITL relative to the implement carrier 1 is known by the control unit CPU (see Figs. 11 and 12). The relevant information, such as the position of the implement turning line and/or the implement working centre relative to the wheels of the implement carrier, may be manually entered into the CPU, or automatically entered, for instance via an ISOBUS connection or RFID. When the position of the implement turning line ITL and/or the implement working centre and the implement ~~trac~~ track line IRCL are known, the control unit CPU may calculate the turning angle for each of the wheels FL, FR, RL, RR (see figure 2) to ensure that the rotational centre axes FLX, FRX, RLX, RRX (see figure 2) and the turning centre of the implement working centre meet in the common vehicle and implement turning centre VTC on the implement turning line ITL, now positioned in front of the front wheels FL, FR. When the implement 5 is front mounted as shown in figure 6, the front wheels FL, FR will turn in the same direction as the rear wheels RL, RR in curves.

Figure 7 illustrates a comparison and operational benefit of the implement carrier 1 comprising the all-wheel steering system AWS in lower part of the figure, versus a conventional front steered tractor 9 in the upper part of the figure, both with a front mounted lawn mower 5b. When the conventional tractor 9 turns, the operational working width WW2 is reduced compared to the implement working width WW1 of the lawn mower 5b, as illustrated. Such a discrepancy will occur in any configuration where the implement turning line ITL is not extending through the vehicle turning centre VTC.

For the implement carrier 1 provided with the all-wheel steering AWS, the actual working width WW2 may always remain equal to the implement working width WW1, since the vehicle turning centre VTC can be aligned with the implement turning line ITL as explained above. For the all-wheel steering system AWS described herein, the vehicle turning centre VTC may be aligned with the implement turning line ITL, regardless of whether the implement 5 is front mounted, mid mounted or rear mounted. The all-wheel steering system AWS may also calculate a correct steering angle when an off-set implement, for instance when an off-set edge cutter (not shown) is connected to the implement carrier 1.

Figure 8 shows an alternative embodiment of the implement carrier 1, where the implement carrier 1 comprises only three wheels, a front wheel FR, a rear wheel RL and a right mid-wheel MR. All wheels FR, MR, RL are individually steerable. The implement carrier 1 is turning around a vehicle turning centre VTC arranged on an implement turning line ITL between the front wheel FR and the rear wheel RL. The rotational centre axes FRX, MRX, RLX meet in the vehicle turning centre VTC together with the turning centre of the implement working centre (IWC).

Figure 9 shows the implement turning line ITL positioned closer to the rear wheels RL, RR than to the front wheels FR, FL. Consequently, the front wheels FR, FL have a larger steering angle than the rear wheels RL, RR. Specific, exemplary steering angles are added to figure 9 for illustration purpose only, to illustrate that all wheels may have different steering angles. The actual steering angles will depend on the length X of the wheelbase, the track width Y, the position of the implement working centre and the working width of the implement.

Figure 10 shows a further alternative embodiment of the implement carrier 1, where the implement carrier comprises six wheels, FR, FL, Mr, ML, RR, RL, all individually steerable. The implement carrier 1 is turning around a vehicle turning centre VTC arranged on an implement turning line ITL positioned behind the rear wheels RL, RR. The illustrated implement turning line ITL coincide with a rear mounted implement. The implement working centre IWC is shown in an off-set position relative to a longitudinal centre axis for the implement carrier 1. When the implement working centre IWC is off-set, the steering angles will be different in a right hand turn and a left hand turn to account for the fact the vehicle turning centre (VTC) and the turning centre of the implement working centre (IWC) are to coincide.

Figure 11 illustrates, on a very schematic level, an exemplary control system for the all-wheel steering system AWS. Four-wheel units 20; here a front wheel left FL, a front wheel right FR, a rear wheel left, RL and a rear wheel right RR, are connected to a control/steering unit CPU. A control signal 21 going from the CPU to each wheel unit 20 activates a steering motor 22 for each of the wheels. In the shown embodiment, a feedback signal 23 from the wheel unit 20 indicates to the CPU the angular position of the wheel. The angular position of the wheel may be measured directly by a (not shown) sensor on the wheel and/or the position of the wheel may be calculated indirectly from an encoder or similar on the steering motor. A power line 25 supplies the steering motors and not shown wheel motors with electric power from a not shown battery. A power feedback signal 26 also controls that each wheel motor rotates at a correct speed. When the wheels turn FR, RL, RR, RL, the control unit CPU adjusts the speed of each of the wheels to ensure that each wheel FR, RL, RR, RL has a correct speed relative to ground, meaning that an outer wheel will rotate faster than an inner wheel. This is done by sending speed signals from the CPU to a separate motor controller for each wheel motor / traction motor, which in turn regulates the traction motor speed accordingly.

Figure 12 shows an exemplary flow diagram for operation of the all-wheel steering system. To start an operation with the implement carrier 1, including an all-wheel steering system according to the invention, the position of the implement work centre entered into the CPU, either manually via a user interface or automatically such as via ISOBUS if this information is readily available when connecting the implement 5 to the implement carrier 1 via the linkage 10 as explained above. The implement carrier 1 is unmanned, meaning that the implement carrier 1 may drive in a fully autonomous mode or in a remote controlled mode. The desired heading / route / implement ~~trac~~ track line IRCL is fed to the control unit / CPU together with heading and speed data collected by GPS. The CPU is also continuously fed the individual, angular positions for each of the wheels, here exemplified with four wheels FL, FR, RL, RR. Based on the input angular positions, the position of the implement work centre IWC and the desired path/IRCL, the control unit is adapted to adjust the angular position

It should be noted that the above-mentioned embodiments illustrate rather than limit the invention, and that those skilled in the art will be able to design many alternative embodiments without departing from the scope of the appended claims. ~~In the claims, any reference signs placed between parentheses shall not be construed as limiting the claim.~~ Use of the verb "comprise”, and its conjugations does not exclude the presence of elements or steps other than those stated in a claim. The article "a" or "an" preceding an element does not exclude the presence of a plurality of such elements.

The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage.

C l a i m s

1. An all-wheel steering system (AWS) for an implement carrier (1), the implement carrier (1) comprising at least one front wheel (FL, FR) and at least one rear wheel (RL, RR), all wheels (FL, FR, RL, RR) being individually steerable, and a linkage for carrying an implement (5), the AWS comprising:
   - a control unit (CPU) and steering means arranged to steer each wheel (FL, FR, RL, RR) so that the rotational centre axes (FLX, FRX, RLX, RRX) for each of the wheels (FL, FR, RL, RR) meet in a vehicle turning centre (VTC) for the implement carrier (1), the VTC being positioned along an implement turning line (ITL) being arranged perpendicularly to a working direction of the implement (5) and trough an implement working centre (IWC) for the implement (5), so that vehicle turning centre (VTC) coincides with a turning centre of the implement working centre (IWC) when the implement carrier (1) turns,
   c h a r a c t e r i z e d i n that the implement turning line (ITL), by means of the control unit, is adapted to be positioned in front of the rear wheels (FL, FR) or behind the front wheels (RL, RR), including a position between the front wheels (FL, FR) and the rear wheels (RL, RR).

2. The steering system (AWS) according to claim 1, where the steering system (AWS) is arranged to position the implement carrier (1) so that the implement turning line (ITL) is perpendicular to an implement track line (IRCL), the implement carrier (1) following the track line (IRCL) or setting the track line (IRCL), the implement track line (IRCL) defining the working direction of the implement.

3. The steering system (AWS) according to claim 2, where the implement working centre (IWC) coincides with the implement track line (IRCL).

4. The steering system (AWS) according to any one of the previous claims, where a position of the implement turning line (ITL) relative to a vehicle reference point (VRP) is set in the control system (CPU) by an operator.

5. The steering system (AWS) according to any one of the previous claims, where the position of the implement turning line (ITL) relative to the vehicle reference point (VRP) is set automatically as the control unit (CPU) receives an electronic signal from the implement.

6. The steering system (AWS) according to claim 5, where the electronic signal is transferred via ISOBUS.

7. The steering system (AWS) according to claim 5, where the electronic signal is transferred via RFID.

8. The steering system (AWS) according to any one of the previous claims, where the steering system (AWS) is remotely operated.

9. The steering system (AWS) according to any one of the previous claims, where the steering system (AWS) is autonomously operated.

10. An implement carrier (1) comprising an all-wheel steering system (AWS) according to any one of the previous claims; the implement carrier (1) comprising a pair of individually steerable front wheels (FL, FR) and a pair of individually steerable rear wheels (RL, RR), and a linkage for carrying an implement (5).

11. The implement carrier (1) according to claim 10, where the linkage is positioned between the front wheels (FL, FR) and the rear wheels (RL, RR).

12. The implement carrier (1) according to claim 10 or 11, where the turning angle of each wheel (FL, FR, RL, RR) is at least 300 degrees.

13. A method for using an implement carrier (1) according to any of the claims 10-12~~3~~, where the method comprises the step of:
- connecting an implement to the implement carrier (1),;
- setting a position of the implement working centre (IWC) relative to a vehicle reference point (VRP);
- aligning the vehicle turning centre (VTC) with the turning centre of the implement working centre (IWC) when the implement carrier (1) turns .

14. A method for using an implement carrier (1) according to claim 13, where the method further comprises the step of:
 - positioning the implement turning line (ITL) in front of the rear wheels (FL, FR) or behind the front wheels (RL, RR), between the front wheels (FL, FR) and the rear wheels (RL, RR).

A b s t r a c t

There is disclosed an all-wheel steering system (AWS) for an implement carrier (1), the implement carrier (1) comprising at least one front wheel (FL, FR) and at least one rear wheel (RL, RR), all wheels (FL, FR, RL, RR) being individually steerable, and a linkage for carrying an implement (5), the AWS comprising:

- a control unit (CPU) and steering means arranged to steer each wheel (FL, FR, RL, RR) so that the rotational centre axes (FLX, FRX, RLX, RRX) for each of the wheels (FL, FR, RL, RR) meet in a vehicle turning centre (VTC) for the implement carrier (1), the VTC being positioned along an implement turning line (ITL) being arranged perpendicularly to a working direction of the implement (5) and trough an implement working centre (IWC) for the implement (5),

c h a r a c t e r i z e d   i n   that the implement turning line (ITL) is positioned in front of the rear wheels (FL, FR) or behind the front wheels (RL, RR), including a position between the front wheels (FL, FR) and the rear wheels (RL, RR).

(Fig. 2)