information. Some modern receivers use selection algorithms to try to determine the most appropriate signal to use in position determination. However, receivers typically cannot differentiate multipath signals from the genuine positioning signals to any high degree of accuracy.

Also known in the art are phased arrays, consisting of a number of antenna elements that can be individually controlled to direct a beam. In a typical phased array, signals received at each element are individually phase and gain manipulated, the exact manipulation required depending on the direction of the beam required. The resulting phase and gain manipulated signals from each element are then summed to obtain the desired direction of the beam.

One method for mitigating the problem of multipath is discussed in published international patent application WO 2011/000049 A1 which is assigned to the present applicant and hereby incorporated in its entirety by reference. This application discusses a method to form a beam using a local receiver antenna to receive a positioning signal from a transmission source, thereby ignoring other signals in a multipath environment.

While this method is successful in mitigating the effects of multipath, the local receiver antenna necessarily requires a number of physical antenna elements. This limits the size to which the local receiver antenna can be miniaturised, and therefore limits the portability of the receiver. Portability is not an issue when the receiving apparatus is to be mounted to, for example, a forklift. However, if receiving apparatus is to be incorporated into, for example, a mobile telephone, then further miniaturisation of the receiver antenna is necessary.

The present invention describes an apparatus and method for utilising antenna technology that is already deployed in portable hand-held equipment in high-precision positioning applications.

SUMMARY OF THE INVENTION

Embodiments~~It is an object~~ of the present invention ~~to~~ overcome or ameliorate at least one of the disadvantages of the prior art, or to provide a useful alternative.

Embodiments~~It is a further object~~ of the present invention ~~to~~ create multiple beams simultaneously.

Embodiments~~It is a further object~~ of the present invention ~~to~~ utilise antenna technology that is already deployed in portable hand-held equipment in high-precision positioning applications.

Embodiments~~It is a further object~~ of the present invention ~~to~~ use a single RF front end for simultaneously forming the multiple beams.

Embodiments~~It is a further object~~ of the present invention ~~to~~ form relatively narrow beams using relatively large numbers of elements (generally more than 32 elements), whilst minimizing electronic complexity.

Embodiments~~It is a further object~~ of the present invention ~~to~~ re-use standard positioning receiver components/logic blocks to reduce power consumption, cost and complexity.

Embodiments~~It is a further object~~ of the present invention ~~to~~ provide a scalable system that is capable of making use of external receiver antennas to increase the precision of the position solution.

Embodiments~~It is a further object~~ of the present invention ~~to~~ provide a method of simultaneously forming multiple beams in different directions using relatively large numbers of elements (generally more than 32 elements) for positioning systems, whist obviating the need for complicated circuitry and calibration.

According to a first aspect, there is provided a device for forming a beam of an antenna array, the device including:

an antenna array having a plurality of spatially distributed antenna elements;

a positioning-unit device coupled with said antenna array, said positioning-unit device configured to switch said antenna elements between first and second states in a predetermined switching sequence wherein, in said first state, said antenna elements are configured to transmit a positioning signal; and

a receiver configured to receive said positioning signal from said antenna array, said receiver having a processor for generating a reference signal, mixing the received positioning signal with a modified reference signal to generate a mixed signal and summing the mixed signal over a predetermined integration period to generate an accumulated signal, wherein said reference signal is modified, in substantial synchronisation with the receipt of the positioning signal from the antenna elements being switched to said first state, prior to being mixed with said received positioning signal such that said accumulated signal is indicative of the direction and magnitude of the beam of the antenna array.

~~According to one aspect of the invention there is provided a device for remotely forming a beam at antenna arrays, the device including:~~

~~an antenna array having a plurality of spatially distributed elements;~~

~~a positioning unit device coupled with said antenna array, said positioning unit device configured to switch said antenna elements between first and second states in a predetermined sequence wherein, in said first state, said elements are configured to transmit a positioning signal; and~~

~~a receiver configured to receive said positioning signal from said antenna array, said receiver having a processor for generating a reference signal, mixing said positioning signal with a modified reference signal to generate a mixed signal and summing the mixed signal over a predetermined integration period to generate an accumulated signal.~~

~~wherein said reference signal is modified prior to being mixed with said received signal such that said accumulated signal is indicative of the direction and magnitude of the beam of the antenna array.~~

Preferably, the receiver includes at least one receive channel having a correlator, wherein the correlator is configured to selectively manipulate the phase and/or gain of the reference signal in substantial synchronism with receipt of the positioning signal.

The positioning signal preferably includes a pseudorandom code having a unique chip sequence within a predefined chip period, the unique chip sequence being used to provide the substantial synchronisation between the reference signal and the positioning signal. Preferably the predetermined integration period is divided into a number of sub-integration periods wherein each of the elements are switched to the first state for the duration of the sub-integration period.

The switching of each element to the first state is preferably aligned to a chip boundary within the unique chip sequence, wherein the sub-integration period is synchronised to begin at the same time as the chip boundary in the next chip period.

Preferably, each sub-integration period is configured to access a respective accumulator for storing the positioning signal, wherein each respective accumulator is mixed with the modified reference signal to generate the mixed signal.

The duration of each sub-integration period within the predetermined integration period is preferably dynamically adjustable such that the positioning signal transmitted from one or more elements are selectively excluded from being mixed with the reference signal.

Preferably, the manipulation of the phase and/or gain is achieved by respectively applying a phase and/or gain offset to the reference signal, wherein the value of the phase and/or gain offset is calculated in dependence upon the predetermined sequence.

The correlator preferably includes a carrier numerical control oscillator (NCO) and the reference signal is synthesised in the carrier NCO.

Preferably, the value of said phase and/or gain offset is calculated by the processor in real time. Alternatively, the value of the phase and/or gain offset is calculated in advance and stored in a database that is available for retrieval by the processor.

Preferably, an element is active in said first state and inactive in said second state. Preferably, elements switched to the second state are configured to be non-resonant such that the effects of mutual-coupling are ameliorated.

Preferably, the antenna elements are spatially distributed in a three dimensional configuration such that the device can form beams in one or more dimensions.

Each receiver preferably includes multiple receive channels, wherein each receive channel is adaptable to form at least one beam.

According to a second aspect, there is provided a device for forming a beam of an antenna array, the device including:

an antenna array having a plurality of spatially distributed antenna elements;

a positioning-unit device coupled with said antenna array, said positioning-unit device configured to:

a) switch said antenna elements between first and second states in a predetermined switching sequence wherein, in said first state, said antenna elements are configured to transmit a positioning signal; and

b) synthesise a positioning signal and modify said positioning signal, in substantial synchronisation with said predetermined switching sequence, to generate a modified positioning signal;

and

a receiver configured to receive said modified positioning signal from said antenna array, said receiver having a processor for generating a reference signal, mixing the received modified positioning signal with said reference signal to generate a mixed signal and summing the mixed signal over a predetermined period to generate an accumulated signal such that said accumulated signal is indicative of the direction and magnitude of the beam of the antenna array.

~~According to another aspect of the invention there is provided a device for remotely forming a beam at an antenna arrays, the device including:~~

an antenna array having a plurality of spatially distributed elements;

a positioning unit device coupled with said antenna array, said positioning unit device configured to

a) switch said antenna elements between first and second states in a predetermined sequence wherein, in said first state, said elements are configured to transmit a modified positioning signal; and

b) synthesise a positioning signal and modify said positioning signal, in substantial synchronism with said predetermined sequence, to generate a modified positioning signal; and

a receiver configured to receive said modified positioning signal from said antenna array, said receiver having a processor for generating a reference signal, mixing said modified positioning signal with said reference signal to generate a mixed signal and summing the mixed signal over a predetermined period to generate an accumulated signal such that said accumulated signal is indicative of the direction and magnitude of the beam of the antenna array.

According to another aspect of the invention there is provided a system for forming composite beams between antenna arrays, the system including:

~~a transmit antenna array having a plurality of spatially distributed elements, said transmit antenna array being coupled to a positioning-unit device that is configured to switch said antenna elements between first and second states in a predetermined sequence wherein, in said first state, said elements are configured to transmit a positioning signal;~~

~~a receive antenna array having a plurality of spatially distributed elements, said receive antenna array being coupled to a positioning receiver that is configured to switch said antenna elements between first and second states in a predetermined sequence wherein, in said first state, said elements are configured to receive a positioning signal; and~~

~~said positioning receiver having a processor configured to:~~

~~receive said positioning signal from said transmit antenna array,~~

~~synthesize a reference signal;~~

~~modify said reference signal in substantial synchronism with the switching of said elements of said transmit and receive antenna arrays to the first state to generate a modified reference signal;~~

~~mix said positioning signal with said modified reference signal to generate a mixed signal; and~~

~~sum the mixed signal over a predetermined period to generate an accumulated signal such that said accumulated signal is indicative of the direction and magnitude of said beam of said transmit and receive antenna arrays.~~

According to a third aspect, there is provided a system for forming composite beams between antenna arrays, the system including:

a transmit antenna array having a plurality of spatially distributed transmit antenna elements, said transmit antenna array being coupled to a positioning-unit device that is configured to switch said transmit antenna elements between first and second states in a first predetermined switching sequence wherein, in said first state, said transmit antenna elements are configured to transmit a positioning signal; and

a receive antenna array having a plurality of spatially distributed receive antenna elements, said receive antenna array being coupled to a positioning receiver that is configured to switch said receive antenna elements between first and second states in a

second predetermined switching sequence wherein, in said first state, said receive antenna elements are configured to receive a positioning signal;

said positioning receiver having a processor configured to:

receive, at said receive antenna array, said positioning signal from said transmit antenna array;

synthesize a reference signal;

modify said reference signal in substantial synchronisation with the receipt of the positioning signal from the transmit antenna elements being switched to said first state, and in substantial synchronisation with the switching of said receive antenna elements to the first state, to generate a modified reference signal;

mix the received positioning signal with said modified reference signal to generate a mixed signal; and

sum the mixed signal over a predetermined integration period to generate an accumulated signal such that said accumulated signal is indicative of the direction and magnitude of a composite beam between said transmit antenna array and said receive antenna array.

~~According to another aspect of the invention there is provided a method for forming a beam at antenna arrays, the method including the steps of:~~

~~a) switching, at a positioning unit device, spatially distributed elements of said antenna array from a second state to a first state in a predetermined sequence, wherein, in said first state, said elements are configured to transmit a positioning signal;~~

~~b) receiving, at a receiver, a positioning signal;~~

~~c) generating, in a correlator of the receiver, a reference signal for correlation with said positioning signal;~~

~~d) applying, in substantial synchronisation with receiving said positioning signals, a predetermined offset to said reference signal to create a modified reference signal;~~

~~e) mixing said positioning signal with said modified reference signal to create a mixed signal; and~~

~~f) accumulating said mixed signal over an integration period to create an accumulated signal, wherein said accumulated signal is indicative of the direction and magnitude of said beam of said antenna array.~~

According to a fourth aspect, there is provided a method for forming a beam of an antenna array, the method including the steps of:

a) switching, at a positioning-unit device, spatially distributed antenna elements of said antenna array from a second state to a first state in a predetermined switching sequence, wherein, in said first state, said antenna elements are configured to transmit a positioning signal;

b) receiving, at a receiver, the positioning signal;

c) generating, in a correlator of the receiver, a reference signal for correlation with the received positioning signal;

d) applying, in substantial synchronisation with the receipt of the positioning signal from the antenna elements being switched to said first state, a predetermined offset to said reference signal to create a modified reference signal;

e) mixing said received positioning signal with said modified reference signal to create a mixed signal; and

f) accumulating said mixed signal over an integration period to create an accumulated signal, wherein said accumulated signal is indicative of the direction and magnitude of said beam of said antenna array.

According to a fifth aspect, there is provided a method for forming composite beams between antenna arrays, the method including the steps of:

a) switching, at a positioning-unit device, spatially distributed transmit antenna elements of a transmit antenna array from a second state to a first state in a first predetermined switching sequence, wherein, in said first state, said transmit antenna elements are configured to transmit a positioning signal;

b) switching, at a positioning receiver, spatially distributed receive antenna elements of a receive antenna array from a second state to a first state in a second predetermined switching sequence, wherein, in said first state, said receive antenna elements are configured to receive a positioning signal;

c) receiving, at said positioning receiver, a positioning signal;

d) generating, in a correlator of said positioning receiver, a reference signal for correlation with the received positioning signal;

e) modifying said reference signal in substantial synchronisation with the receipt of the positioning signal from the transmit antenna elements being switched to said first state, and in substantial synchronisation with the switching of the receive antenna elements to the first state, to generate a modified reference signal;

f) mixing said received positioning signal with said modified reference signal to create a mixed signal; and

g) accumulating said mixed signal over an integration period to create an accumulated signal, wherein said accumulated signal is indicative of the direction and magnitude of a composite beam between said transmit antenna array and said receive antenna array.

~~According to another aspect of the invention there is provided a method for forming composite beams between antenna arrays, the method including the steps of:~~

~~a) switching, at a positioning unit device, spatially distributed elements of a transmit antenna array from a second state to a first state in a predetermined sequence, wherein, in said first state, said elements are configured to transmit a positioning signal;~~

~~b) switching, at a positioning receiver, spatially distributed elements of a receive antenna array from a second state to a first state in a predetermined sequence, wherein, in said first state, said elements are configured to receive a positioning signal;~~

~~c) receiving, at a positioning receiver, a positioning signal;~~

~~d) generating, in a correlator of said positioning receiver, a reference signal for correlation with said positioning signal;~~

~~e) modifying said reference signal in substantial synchronism with the switching of said elements of said transmit and receive antenna arrays to the first state to generate a modified reference signal;~~

~~f) mixing said positioning signal with said modified reference signal to create a mixed signal; and~~

~~g) accumulating said mixed signal over an integration period to create an accumulated signal, wherein said accumulated signal is indicative of the direction and magnitude of said beam of said transmit and receive antenna arrays.~~

~~According to another aspect of the invention there is provided a method for forming a beam at antenna arrays, the method including the steps of:~~

~~a) synthesising, in a positioning-unit device, a positioning signal;~~

~~b) switching, at a positioning-unit device, spatially-distributed elements of said antenna array from a second state to a first state in a predetermined sequence, wherein, in said first state, said elements are configured to transmit a modified positioning signal;~~

~~c) applying, in substantial synchronisation with the switching of one of said elements to the first state, a predetermined offset to said positioning signal to create said modified positioning signal;~~

~~d) receiving, at a receiver, said modified positioning signal;~~

~~e) generating, in a correlator of the receiver, a reference signal for correlation with said modified positioning signal;~~

~~f) mixing said modified positioning signal with said reference signal to create a mixed signal; and~~

~~g) accumulating said mixed signal over an integration period to create an accumulated signal, wherein said accumulated signal is indicative of the direction and magnitude of said beam of said antenna array.~~

In a sixth aspect, there is provided a method for forming a beam of an antenna array, the method including the steps of:

a) synthesising, in a positioning-unit device, a positioning signal;

b) switching, at said positioning-unit device, spatially distributed antenna elements of said antenna array from a second state to a first state in a predetermined switching sequence, wherein, in said first state, said antenna elements are configured to transmit a positioning signal;

c) applying, in substantial synchronisation with the switching of one of said antenna elements to the first state, a predetermined offset to said positioning signal to create a modified positioning signal;

d) receiving, at a receiver, said modified positioning signal;

e) generating, in a correlator of the receiver, a reference signal for correlation with the received modified positioning signal;

f) mixing said received modified positioning signal with said reference signal to create a mixed signal; and

g) accumulating said mixed signal over an integration period to create an accumulated signal, wherein said accumulated signal is indicative of the direction and magnitude of said beam of said antenna array.

BRIEF DESCRIPTION OF THE DRAWINGS

A preferred embodiment of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

FIG. 1 is a schematic view of an antenna array coupled with a positioning-unit device according to one aspect of the invention;

FIG. 2 is a schematic view of the positioning receiver of Figure 1 coupled to an omni-directional antenna showing some internal components of the receiver according to one aspect of the invention;

FIG. 3 is a schematic view of a beam locally formed by the positioning receiver interacting with a beam remotely formed by the antenna array of Figure 1;

FIG. 4a is a timing diagram showing the relationship between B-slots, R-slots and the integration period according to one aspect of the invention;

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1 A device for remotely forming a beam at antenna arrays, the device including:

an antenna array having a plurality of spatially distributed elements;

a positioning-unit device coupled with said antenna array, said positioning-unit device configured to switch said antenna elements between first and second states in a predetermined sequence wherein, in said first state, said elements are configured to transmit a positioning signal; and

a receiver configured to receive said positioning signal from said antenna array, said receiver having a processor for generating a reference signal, mixing said positioning signal with a modified reference signal to generate a mixed signal and summing the mixed signal over a predetermined integration period to generate an accumulated signal, wherein said reference signal is modified prior to being mixed with said received signal such that said accumulated signal is indicative of the direction and magnitude of the beam of the antenna array.

2 A device according to claim 1 wherein said receiver includes at least one receive channel having a correlator, wherein said correlator is configured to selectively manipulate the phase and/or gain of said reference signal in substantial synchronisation with said predetermined sequence.

3 A device according to claim 2 wherein said positioning signal includes a pseudorandom code having a unique chip sequence within a predefined chip period, said unique chip sequence being used to provide said substantial synchronisation.

4 A device according to claim 3 wherein said predetermined integration period is divided into a number of sub-integration periods wherein each of said elements are switched to said first state for the duration of said sub-integration period.

5 A device according to claim 4 wherein the switching of each said element to said first state is aligned to a chip boundary within said unique chip sequence, wherein said sub-integration period is synchronised to begin at the same time as said chip boundary in the next chip period.

6 A device according to claim 4 wherein each sub-integration period is configured to access a respective accumulator for storing said positioning signal, wherein each said respective accumulator is mixed with said modified reference signal to generate said mixed signal.

7 A device according to claim 4 wherein the duration of each sub-integration period within said predetermined integration period is dynamically adjustable such that the positioning signal transmitted from one or more elements are selectively excluded from being mixed with said reference signal.

8 A device according to claim 2 wherein the manipulation of said phase and/or gain is achieved by respectively applying a phase and/or gain offset to said reference signal, wherein the value of said phase and/or gain offset is calculated in dependence upon said predetermined sequence.

9 A device according to claim 2 wherein said correlator includes a carrier numerical control oscillator (NCO) and said reference signal is synthesised in said carrier NCO.

10 A device according to claim 8 wherein the value of said phase and/or gain offset is calculated by said processor in real time.

11 A device according to claim 8 wherein the value of said phase and/or gain offset is calculated in advance and stored in a database that is available for retrieval by said processor.

12 A device according to claim 1 wherein in said first state, said element is active and in said second state, said element is inactive.

13 A device according to claim 1 wherein said antenna elements are spatially distributed in a three dimensional configuration such that the device can form beams in one or more dimensions.

14 A device according to claim 1 wherein each receiver includes multiple receive channels, wherein each receive channel is adaptable to form at least one beam.

15 A device according to claim 1 wherein elements switched to the second state are configured to be non-resonant such that the effects of mutual-coupling are ameliorated.

18 A device for remotely forming a beam at an antenna arrays, the device including:

an antenna array having a plurality of spatially distributed elements;

a positioning-unit device coupled with said antenna array, said positioning-unit device configured to

a) switch said antenna elements between first and second states in a predetermined sequence wherein, in said first state, said elements are configured to transmit a modified positioning signal; and

b) synthesise a positioning signal and modify said positioning signal, in substantial synchronism with said predetermined sequence, to generate a modified positioning signal; and

a receiver configured to receive said modified positioning signal from said antenna array, said receiver having a processor for generating a reference signal, mixing said modified positioning signal with said reference signal to generate a mixed signal and summing the mixed signal over a predetermined period to generate an accumulated signal such that said accumulated signal is indicative of the direction and magnitude of the beam of the antenna array.

19 A system for forming composite beams between antenna arrays, the system including:

a transmit antenna array having a plurality of spatially distributed elements, said transmit antenna array being coupled to a positioning-unit device that is configured to switch said antenna elements between first and second states in a predetermined sequence wherein, in said first state, said elements are configured to transmit a positioning signal;

a receive antenna array having a plurality of spatially distributed elements, said receive antenna array being coupled to a positioning receiver that is configured to switch said antenna elements between first and second states in a predetermined sequence wherein, in said first state, said elements are configured to receive a positioning signal; and

said positioning receiver having a processor configured to:

receive said positioning signal from said transmit antenna array,

synthesize a reference signal:

modify said reference signal in substantial synchronism with the switching of said elements of said transmit and receive antenna arrays to the first state to generate a modified reference signal;

mix said positioning signal with said modified reference signal to generate a mixed signal; and

sum the mixed signal over a predetermined period to generate an accumulated signal such that said accumulated signal is indicative of the direction and magnitude of said beam of said transmit and receive antenna arrays.

A method for forming a beam at antenna arrays, the method including the steps of:

a) switching, at a positioning-unit device, spatially distributed elements of said antenna array from a second state to a first state in a predetermined sequence, wherein, in said first state, said elements are configured to transmit a positioning signal;

b) receiving, at a receiver, a positioning signal;

c) generating, in a correlator of the receiver, a reference signal for correlation with said positioning signal;

d) applying, in substantial synchronisation with receiving said positioning signals, a predetermined offset to said reference signal to create a modified reference signal;

e) mixing said positioning signal with said modified reference signal to create a mixed signal; and

f) accumulating said mixed signal over an integration period to create an accumulated signal, wherein said accumulated signal is indicative of the direction and magnitude of said beam of said antenna array.

A method for forming composite beams between antenna arrays, the method including the steps of:

a) switching, at a positioning-unit device, spatially distributed elements of a transmit antenna array from a second state to a first state in a predetermined sequence, wherein, in said first state, said elements are configured to transmit a positioning signal;

b) switching, at a positioning receiver, spatially distributed elements of a receive antenna array from a second state to a first state in a predetermined sequence, wherein, in said first state, said elements are configured to receive a positioning signal;

c) receiving, at a positioning receiver, a positioning signal;

d) generating, in a correlator of said positioning receiver, a reference signal for correlation with said positioning signal;

e) modifying said reference signal in substantial synchronism with the switching of said elements of said transmit and receive antenna arrays to the first state to generate a modified reference signal;

f) mixing said positioning signal with said modified reference signal to create a mixed signal; and

g) accumulating said mixed signal over an integration period to create an accumulated signal, wherein said accumulated signal is indicative of the direction and magnitude of said beam of said transmit and receive antenna arrays.

21 A method for forming a beam at antenna arrays, the method including the steps of:

a) synthesising, in a positioning-unit device, a positioning signal;

b) switching, at a positioning-unit device, spatially distributed elements of said antenna array from a second state to a first state in a predetermined sequence, wherein, in said first state, said elements are configured to transmit a modified positioning signal;

c) applying, in substantial synchronisation with the switching of one of said elements to the first state, a predetermined offset to said positioning signal to create said modified positioning signal;

d) receiving, at a receiver, said modified positioning signal;

e) generating, in a correlator of the receiver, a reference signal for correlation with said modified positioning signal;

f) mixing said modified positioning signal with said reference signal to create a mixed signal; and

g) accumulating said mixed signal over an integration period to create an accumulated signal, wherein said accumulated signal is indicative of the direction and magnitude of said beam of said antenna array.

AMENDED CLAIMS
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1 A device for remotely forming a beam at antenna arrays, the device including:

an antenna array having a plurality of spatially distributed elements;

a positioning-unit device coupled with said antenna array, said positioning-unit device configured to switch said antenna elements between first and second states in a predetermined sequence wherein, in said first state, said elements are configured to transmit a positioning signal; and

a receiver configured to receive said positioning signal from said antenna array, said receiver having a processor for generating a reference signal, mixing said positioning signal with a modified reference signal to generate a mixed signal and summing the mixed signal over a predetermined integration period to generate an accumulated signal, wherein said reference signal is modified prior to being mixed with said received signal such that said accumulated signal is indicative of the direction and magnitude of the beam of the antenna array.

2 A device according to claim 1 wherein said receiver includes at least one receive channel having a correlator, wherein said correlator is configured to selectively manipulate the phase and/or gain of said reference signal in substantial synchronisation with said predetermined sequence.

3 A device according to claim 2 wherein said positioning signal includes a pseudorandom code having a unique chip sequence within a predefined chip period, said unique chip sequence being used to provide said substantial synchronisation.

4 A device according to claim 3 wherein said predetermined integration period is divided into a number of sub-integration periods wherein each of said elements are switched to said first state for the duration of said sub-integration period.

5 A device according to claim 4 wherein the switching of each said element to said first state is aligned to a chip boundary within said unique chip sequence, wherein said sub-integration period is synchronised to begin at the same time as said chip boundary in the next chip period.

6 A device according to claim 4 wherein each sub-integration period is configured to access a respective accumulator for storing said positioning signal, wherein each said respective accumulator is mixed with said modified reference signal to generate said mixed signal.

7 A device according to claim 4 wherein the duration of each sub-integration period within said predetermined integration period is dynamically adjustable such that the positioning signal transmitted from one or more elements are selectively excluded from being mixed with said reference signal.

8 A device according to claim 2 wherein the manipulation of said phase and/or gain is achieved by respectively applying a phase and/or gain offset to said reference signal, wherein the value of said phase and/or gain offset is calculated in dependence upon said predetermined sequence.

9 A device according to claim 2 wherein said correlator includes a carrier numerical control oscillator (NCO) and said reference signal is synthesised in said carrier NCO.

10 A device according to claim 8 wherein the value of said phase and/or gain offset is calculated by said processor in real time.

11 A device according to claim 8 wherein the value of said phase and/or gain offset is calculated in advance and stored in a database that is available for retrieval by said processor.

12 A device according to claim 1 wherein in said first state, said elements are active and in said second state, said elements are inactive.

13 A device according to claim 1 wherein said antenna elements are spatially distributed in a three dimensional configuration such that the device can form beams in one or more dimensions.

14 A device according to claim 1 wherein each receiver includes multiple receive channels, wherein each receive channel is adaptable to form at least one beam.

15 A device according to claim 1 wherein elements switched to the second state are configured to be non-resonant such that the effects of mutual-coupling are ameliorated.

16 A device for remotely forming a beam at an antenna arrays, the device including:

an antenna array having a plurality of spatially distributed elements;

a positioning-unit device coupled with said antenna array, said positioning-unit device configured to

a) switch said antenna elements between first and second states in a predetermined sequence wherein, in said first state, said elements are configured to transmit a modified positioning signal; and

b) synthesise a positioning signal and modify said positioning signal, in substantial synchronism with said predetermined sequence, to generate a modified positioning signal; and

a receiver configured to receive said modified positioning signal from said antenna array, said receiver having a processor for generating a reference signal, mixing said modified positioning signal with said reference signal to generate a mixed signal and summing the mixed signal over a predetermined period to generate an accumulated signal such that said accumulated signal is indicative of the direction and magnitude of the beam of the antenna array.

17 A system for forming composite beams between antenna arrays, the system including:

a transmit antenna array having a plurality of spatially distributed elements, said transmit antenna array being coupled to a positioning-unit device that is configured to switch said antenna elements between first and second states in a predetermined sequence wherein, in said first state, said elements are configured to transmit a positioning signal;

a receive antenna array having a plurality of spatially distributed elements, said receive antenna array being coupled to a positioning receiver that is configured to switch said antenna elements between first and second states in a predetermined sequence wherein, in said first state, said elements are configured to receive a positioning signal; and

said positioning receiver having a processor configured to:

receive said positioning signal from said transmit antenna array,

synthesize a reference signal:

modify said reference signal in substantial synchronism with the switching of said elements of said transmit and receive antenna arrays to the first state to generate a modified reference signal;

mix said positioning signal with said modified reference signal to generate a mixed signal; and

sum the mixed signal over a predetermined period to generate an accumulated signal such that said accumulated signal is indicative of the direction and magnitude of said beam of said transmit and receive antenna arrays.

18 A method for forming a beam at antenna arrays, the method including the steps of:

a) switching, at a positioning unit device, spatially distributed elements of said antenna array from a second state to a first state in a predetermined sequence, wherein, in said first state, said elements are configured to transmit a positioning signal;

b) receiving, at a receiver, a positioning signal;

c) generating, in a correlator of the receiver, a reference signal for correlation with said positioning signal;

d) applying, in substantial synchronisation with receiving said positioning signals, a predetermined offset to said reference signal to create a modified reference signal;

e) mixing said positioning signal with said modified reference signal to create a mixed signal; and

f) accumulating said mixed signal over an integration period to create an accumulated signal, wherein said accumulated signal is indicative of the direction and magnitude of said beam of said antenna array.

19 A method for forming composite beams between antenna arrays, the method including the steps of:

a) switching, at a positioning-unit device, spatially distributed elements of a transmit antenna array from a second state to a first state in a predetermined sequence, wherein, in said first state, said elements are configured to transmit a positioning signal;

b) switching, at a positioning receiver, spatially distributed elements of a receive antenna array from a second state to a first state in a predetermined sequence, wherein, in said first state, said elements are configured to receive a positioning signal;

c) receiving, at a positioning receiver, a positioning signal;

d) generating, in a correlator of said positioning receiver, a reference signal for correlation with said positioning signal;

e) modifying said reference signal in substantial synchronism with the switching of said elements of said transmit and receive antenna arrays to the first state to generate a modified reference signal;

f) mixing said positioning signal with said modified reference signal to create a mixed signal; and

g) accumulating said mixed signal over an integration period to create an accumulated signal, wherein said accumulated signal is indicative of the direction and magnitude of said beam of said transmit and receive antenna arrays.

A method for forming a beam at antenna arrays, the method including the steps of:

a) synthesising, in a positioning-unit device, a positioning signal;

b) switching, at a positioning-unit device, spatially distributed elements of said antenna array from a second state to a first state in a predetermined sequence, wherein, in said first state, said elements are configured to transmit a modified positioning signal;

c) applying, in substantial synchronisation with the switching of one of said elements to the first state, a predetermined offset to said positioning signal to create said modified positioning signal;

d) receiving, at a receiver, said modified positioning signal;

e) generating, in a correlator of the receiver, a reference signal for correlation with said modified positioning signal;

f) mixing said modified positioning signal with said reference signal to create a mixed signal; and

g) accumulating said mixed signal over an integration period to create an accumulated signal, wherein said accumulated signal is indicative of the direction and magnitude of said beam of said antenna array.

We claim:

1. A device for forming a beam of an antenna array, the device including:

an antenna array having a plurality of spatially distributed antenna elements;

a positioning-unit device coupled with said antenna array, said positioning-unit device configured to switch said antenna elements between first and second states in a predetermined switching sequence wherein, in said first state, said antenna elements are configured to transmit a positioning signal; and

a receiver configured to receive said positioning signal from said antenna array, said receiver having a processor for generating a reference signal, mixing the received positioning signal with a modified reference signal to generate a mixed signal and summing the mixed signal over a predetermined integration period to generate an accumulated signal, wherein said reference signal is modified, in substantial synchronisation with the receipt of the positioning signal from the antenna elements being switched to said first state, prior to being mixed with said received positioning signal such that said accumulated signal is indicative of the direction and magnitude of the beam of the antenna array.

2. A device according to claim 1, wherein said receiver includes at least one receive channel having a correlator, wherein said correlator is configured to selectively manipulate the phase and/or gain of said reference signal in substantial synchronisation with the receipt of the positioning signal from the antenna elements being switched to said first state.

3. A device according to claim 2, wherein said positioning signal includes a pseudorandom code having a unique chip sequence, said unique chip sequence being used to provide said substantial synchronisation.

4. A device according to any one of claims 1 to 3, wherein said device is configured to take into account a transmission delay that occurs between generation of said positioning signal and transmission of said positioning signal through said antenna elements.

5. A device according to claim 2 or claim 3, wherein the manipulation of said phase and/or gain is achieved by respectively applying a phase and/or gain offset to said

reference signal, wherein the value of said phase and/or gain offset is calculated in dependence upon said predetermined switching sequence.

6. A device according to claim 2 or claim 3, wherein said correlator includes a carrier numerically controlled oscillator (NCO) and said reference signal is synthesised in said carrier NCO.

7. A device according to any one of claims 1 to 6, wherein said antenna elements are spatially distributed in a three dimensional configuration such that the device can form beams in one or more dimensions.

8. A device according to any one of claims 1 to 7, wherein said receiver includes multiple receive channels, wherein each receive channel is adaptable to form at least one beam.

9. A device according to any one of claims 1 to 8, wherein antenna elements switched to the second state are configured to be non-resonant such that the effects of mutual-coupling are ameliorated.

10. A device for forming a beam of an antenna array, the device including:

an antenna array having a plurality of spatially distributed antenna elements;

a positioning-unit device coupled with said antenna array, said positioning-unit device configured to:

a) switch said antenna elements between first and second states in a predetermined switching sequence wherein, in said first state, said antenna elements are configured to transmit a positioning signal; and

b) synthesise a positioning signal and modify said positioning signal, in substantial synchronisation with said predetermined switching sequence, to generate a modified positioning signal;

and

a receiver configured to receive said modified positioning signal from said antenna array, said receiver having a processor for generating a reference signal, mixing the received modified positioning signal with said reference signal to generate a mixed signal and summing the mixed signal over a predetermined period to generate an accumulated signal such that said accumulated signal is indicative of the direction and magnitude of the beam of the antenna array.

11. A system for forming composite beams between antenna arrays, the system including:

a transmit antenna array having a plurality of spatially distributed transmit antenna elements, said transmit antenna array being coupled to a positioning-unit device that is configured to switch said transmit antenna elements between first and second states in a first predetermined switching sequence wherein, in said first state, said transmit antenna elements are configured to transmit a positioning signal; and

a receive antenna array having a plurality of spatially distributed receive antenna elements, said receive antenna array being coupled to a positioning receiver that is configured to switch said receive antenna elements between first and second states in a second predetermined switching sequence wherein, in said first state, said receive antenna elements are configured to receive a positioning signal;

said positioning receiver having a processor configured to:

receive, at said receive antenna array, said positioning signal from said transmit antenna array;

synthesize a reference signal;

modify said reference signal in substantial synchronisation with the receipt of the positioning signal from the transmit antenna elements being switched to said first state, and in substantial synchronisation with the switching of said receive antenna elements to the first state, to generate a modified reference signal;

mix the received positioning signal with said modified reference signal to generate a mixed signal; and

sum the mixed signal over a predetermined integration period to generate an accumulated signal such that said accumulated signal is indicative of the direction and magnitude of a composite beam between said transmit antenna array and said receive antenna array.

12. A system according to claim 11, wherein said positioning receiver includes at least one receive channel having a correlator, wherein said correlator is configured to selectively manipulate the phase and/or gain of said reference signal in substantial synchronisation with the receipt of the positioning signal from the transmit antenna elements being switched to said first state, and in substantial synchronisation with the switching of the receive antenna elements to said first state.

13. A system according to claim 12, wherein said positioning signal includes a pseudorandom code having a unique chip sequence, said unique chip sequence being used to provide the substantial synchronisation with the receipt of the positioning signal from the transmit antenna elements being switched to said first state.

14. A system according to any one of claims 11 to 13, wherein said system is configured to take into account a transmission delay that occurs between generation of said positioning signal and transmission of said positioning signal through said transmit antenna elements.

15. A system according to any one of claims 11 to 14, wherein said predetermined integration period is divided into a number of sub-integration periods which are determined by the overlap of the periods of receipt of the positioning signal from the transmit antenna elements being switched to said first state, and the periods of the switching of the receive antenna elements to said first state.

16. A system according to claim 12 or claim 13, wherein the manipulation of said phase and/or gain is achieved by respectively applying a phase and/or gain offset to said reference signal, wherein the value of said phase and/or gain offset is calculated in dependence upon said first and second predetermined switching sequences.

17. A method for forming a beam of an antenna array, the method including the steps of:

a) switching, at a positioning-unit device, spatially distributed antenna elements of said antenna array from a second state to a first state in a predetermined switching sequence, wherein, in said first state, said antenna elements are configured to transmit a positioning signal;

b) receiving, at a receiver, the positioning signal;

c) generating, in a correlator of the receiver, a reference signal for correlation with the received positioning signal;

d) applying, in substantial synchronisation with the receipt of the positioning signal from the antenna elements being switched to said first state, a predetermined offset to said reference signal to create a modified reference signal;

e) mixing said received positioning signal with said modified reference signal to create a mixed signal; and

f) accumulating said mixed signal over an integration period to create an accumulated signal, wherein said accumulated signal is indicative of the direction and magnitude of said beam of said antenna array.

18. A method according to claim 17, wherein the step of applying a predetermined offset to said reference signal comprises selective manipulation of the phase and/or gain of said reference signal in substantial synchronisation with the receipt of the positioning signal from the antenna elements being switched to said first state.

19. A method according to claim 18, wherein said positioning signal includes a pseudorandom code having a unique chip sequence, said unique chip sequence being used to provide said substantial synchronisation.

20. A method according to any one of claims 17 to 19, further comprising the step of taking into account a transmission delay that occurs between generation of said positioning signal and transmission of said positioning signal through said antenna elements.

21. A method according to claim 18 or claim 19, wherein the gain and/or phase manipulations are applied to said reference signal throughout the entirety of the allocated periods of receipt of the positioning signal from the antenna elements being switched to said first state.

22. A method according to claim 18 or claim 19, wherein the manipulation of said phase and/or gain is achieved by respectively applying a phase and/or gain offset to said reference signal, wherein the value of said phase and/or gain offset is calculated in dependence upon said predetermined switching sequence.

23. A method according to claim 22, wherein the value of said phase and/or gain offset is calculated in real time, or is calculated in advance and stored in a database that is available for retrieval.

24. A method for forming composite beams between antenna arrays, the method including the steps of:

a) switching, at a positioning-unit device, spatially distributed transmit antenna elements of a transmit antenna array from a second state to a first state in a first

predetermined switching sequence, wherein, in said first state, said transmit antenna elements are configured to transmit a positioning signal;

b) switching, at a positioning receiver, spatially distributed receive antenna elements of a receive antenna array from a second state to a first state in a second predetermined switching sequence, wherein, in said first state, said receive antenna elements are configured to receive a positioning signal;

c) receiving, at said positioning receiver, a positioning signal;

d) generating, in a correlator of said positioning receiver, a reference signal for correlation with the received positioning signal;

e) modifying said reference signal in substantial synchronisation with the receipt of the positioning signal from the transmit antenna elements being switched to said first state, and in substantial synchronisation with the switching of the receive antenna elements to the first state, to generate a modified reference signal;

f) mixing said received positioning signal with said modified reference signal to create a mixed signal; and

g) accumulating said mixed signal over an integration period to create an accumulated signal, wherein said accumulated signal is indicative of the direction and magnitude of a composite beam between said transmit antenna array and said receive antenna array.

25. A method according to claim 24, wherein the step of modifying said reference signal comprises selective manipulation of the phase and/or gain of said reference signal in substantial synchronisation with the receipt of the positioning signal from the transmit antenna elements being switched to said first state, and in substantial synchronisation with the switching of the receive antenna elements to said first state.

26. A method according to claim 25, wherein said positioning signal includes a pseudorandom code having a unique chip sequence, said unique chip sequence being used to provide the substantial synchronisation with the receipt of the positioning signal from the transmit antenna elements being switched to said first state.

27. A method according to any one of claims 24 to 26, further comprising the step of taking into account a transmission delay that occurs between generation of said positioning signal and transmission of said positioning signal through said transmit antenna elements.

28. A method according to any one of claims 24 to 27, wherein said integration period is divided into a number of sub-integration periods which are determined by the overlap of the periods of receipt of the positioning signal from the transmit antenna elements being switched to said first state, and the periods of the switching of the receive antenna elements to said first state.

29. A method according to claim 25 or claim 26, wherein the manipulation of said phase and/or gain is achieved by respectively applying a phase and/or gain offset to said reference signal, wherein the value of said phase and/or gain offset is calculated in dependence upon said first and second predetermined switching sequences.

30. A method for forming a beam of an antenna array, the method including the steps of:

a) synthesising, in a positioning-unit device, a positioning signal;

b) switching, at said positioning-unit device, spatially distributed antenna elements of said antenna array from a second state to a first state in a predetermined switching sequence, wherein, in said first state, said antenna elements are configured to transmit a positioning signal;

c) applying, in substantial synchronisation with the switching of one of said antenna elements to the first state, a predetermined offset to said positioning signal to create a modified positioning signal;

d) receiving, at a receiver, said modified positioning signal;

e) generating, in a correlator of the receiver, a reference signal for correlation with the received modified positioning signal;

f) mixing said received modified positioning signal with said reference signal to create a mixed signal; and

g) accumulating said mixed signal over an integration period to create an accumulated signal, wherein said accumulated signal is indicative of the direction and magnitude of said beam of said antenna array.