The synchronisation methods disclosed in US 7,616,682 require each positioning-unit device to account for the propagation delay for reference signals transmitted from the reference device, which it typically calculates by dividing the geometric distance, i.e. straight-line distance between the respective antennas, by the speed of light. The positioning-unit devices are expected to know the geometric distances *a priori*, e.g. from prior surveying of their own antenna positions and that of the reference device antenna positions, with the reference device able to broadcast its antenna position as part of the data component of its signal.

There are however situations where it may be impractical or impossible for a positioning-unit device to have *a priori* knowledge of the geometric distance to the reference device. For example the positions of the reference device or the positioning-unit device may be unknown, or it may be impermissible or undesirable for the reference device to broadcast its position. The accuracy of the prior art synchronisation methods will also be compromised if the geometric distance does not represent the actual propagation path for signals from the reference device, e.g. because of multipath or if the signals are propagated through fixed lines.

There exists a need for improved methods and apparatus for synchronising the signal of a positioning-unit device to the timebase of a reference device. In particular, there is a need to be able to measure the propagation delay for reference signals being transmitted from a reference device to a positioning-unit device when the geometric distance or propagation delay is unknown.

Definitions

In the description herein and in the claims that follow, the terms ‘comprising’, ‘comprises’ and the like are to be interpreted in an inclusive sense, synonymous with the terms ‘including’, ‘includes’ and the like. For example the expression ‘an apparatus comprising A and B’ should not be limited to apparatus consisting only of elements A and B. Similarly, the term ‘or’ is to be interpreted in an inclusive rather than an exclusive sense. For example unless the context clearly requires otherwise, the expression ‘A or B’ is to be interpreted as meaning A, or B, or both A and B.

Embodiments of the Invention

Embodiments of the present invention seek to overcome or ameliorate at least one of the disadvantages of the prior art, or to provide a useful alternative. Embodiments of the present invention provide a method and apparatus for synchronising the signal of a positioning-unit device

to the timebase of a reference device, in situations where the positions of one or both of the devices are unknown or classified, or where the reference signal propagation delay is otherwise *a priori* unknown.

Summary of the Invention

According to a first aspect of the present invention there is provided a method for synchronising a second signal generated and transmitted by a second device to a timebase of a first device, said method comprising the steps of:

(i) said first device generating and transmitting a first signal comprising first time information indicating the time of transmission of said first signal according to the timebase of said first device;

(ii) said second device:

(a) receiving and interpreting said first signal;

(b) generating and transmitting said second signal comprising second time information indicating the time of transmission of said second signal;

(c) receiving said second signal via a feedback loop and interpreting said second signal;

(d) calculating a first time difference between said first time information and said second time information; and

(e) adjusting the generation of said second signal according to said first time difference, thereby adjusting said second signal and said second time information;

(iii) said first device:

(a) receiving said first signal via a feedback loop, receiving the adjusted second signal and interpreting said first signal and said adjusted second signal;

(b) calculating a second time difference between said first time information and the adjusted second time information; and

(c) transmitting said second time difference, or a quantity related thereto; and

(iv) said second device:

(a) receiving said second time difference or the related quantity and obtaining therefrom a measure of the propagation delay of said first signal; and

(b) adjusting the generation of said second signal according to said measure of said propagation delay,

thereby synchronising said second signal to said timebase.

Step (ii) (e) preferably comprises adjusting the generation of the second signal so as to minimise the difference between the first time information and the second time information.

Preferably, the method further comprises the steps of the first device after the second signal has been synchronised to the timebase:

receiving and interpreting the second signal and the first signal;

measuring a phase or time difference between the received and interpreted first and second signals; and

transmitting the measured phase or time difference or a related quantity,

such that the second device can adjust the generation of the second signal to mitigate the effect on the synchronisation of the second signal to the timebase of environment-related variations in the propagation of the first signal.

More preferably, the second device adjusts the generation of the second signal according to the measured phase or time difference or related quantity.

In certain embodiments the first and second signals are transmitted between the first and second devices via a fixed line. The fixed line may comprise a coaxial cable or an optical fibre.

In certain embodiments the method further comprises the step of broadcasting, from a transmitter operatively associated with the second device, a third signal that is synchronised with the timebase.

According to a second aspect of the present invention there is provided, in an apparatus in which a second device generating and transmitting a second signal has nominally synchronised said second signal to the timebase of a first device generating and transmitting a first signal, using a nominal value for the propagation delay of said first signal from said first device to said second device, a method for identifying a time residual between said second signal and said timebase, said method comprising the steps of said first device:

a) receiving said first signal via a feedback loop, receiving said second signal and interpreting said first signal and said second signal;

b) measuring a time difference between the received first signal and the received second signal, from which said time residual can be calculated; and

c) transmitting the measured time difference or a related quantity, such that said time residual can be corrected or compensated for.

In preferred embodiments the second device utilises the measured time difference or related quantity to adjust the generation of the second signal, thereby improving the accuracy of the synchronisation of the second signal to the timebase.

In other embodiments a third device utilises the measured time difference or related quantity to apply a correction to signals received from the second device.

In certain embodiments the method further comprises the steps of the first device after the second device has adjusted the generation of the second signal:

receiving and interpreting the second signal and the first signal;

measuring a phase or time difference between the received and interpreted first and second signals; and

transmitting the measured phase or time difference or a related quantity,

such that the second device can adjust the generation of the second signal to mitigate the effect on the synchronisation of the second signal to the timebase of environment-related variations in the propagation of the first signal.

According to a third aspect of the present invention there is provided a system for synchronising a second signal generated and transmitted by a second device to a timebase of a first device, said system comprising:

a first device configured to generate and transmit a first signal comprising first time information indicating the time of transmission of said first signal according to a timebase of said first device; and

a second device configured to:

receive and interpret said first signal;

generate and transmit a second signal comprising second time information indicating the time of transmission of said second signal;

receive said second signal via a feedback loop and interpret said second signal;

calculate a first time difference between said first time information and said second time information; and

adjust the generation of said second signal according to said first time difference, thereby adjusting said second signal and said second time information;

wherein said first device is further configured to:

receive said first signal via a feedback loop, receive the adjusted second signal and interpret said first signal and said adjusted second signal;

calculate a second time difference between said first time information and the adjusted second time information; and

transmit said second time difference, or a quantity related thereto;

and wherein said second device is further configured to:

receive said second time difference or the related quantity and obtain therefrom a measure of the propagation delay of said first signal; and

adjust the generation of said second signal according to said measure of said propagation delay,

thereby synchronising said second signal to said timebase.

Preferably, the second device is configured to adjust the generation of the second signal according to the first time difference so as to minimise the difference between the first time information and the second time information.

Preferably, the first device is configured to, after the second signal has been synchronised to the timebase:

receive and interpret the second signal and the first signal;

measure a phase or time difference between the received and interpreted first and second signals; and

transmit the measured phase or time difference or a related quantity,

such that the second device can adjust the generation of the second signal to mitigate the effect on the synchronisation of the second signal to the timebase of environment-related variations in the propagation of the first signal.

More preferably, the second device is configured to adjust the generation of the second signal according to the measured phase or time difference or related quantity.

In certain embodiments the first and second devices are configured to transmit and receive the first and second signals via a fixed line connecting the first and second devices. The fixed line may comprise a coaxial cable or an optical fibre.

In certain embodiments the apparatus further comprises a transmitter operatively associated with the second device, for broadcasting a third signal that is synchronised with the timebase.

According to a fourth aspect of the present invention there is provided an apparatus for identifying a time residual between a second signal generated and transmitted by a second device and a timebase of a first device generating and transmitting a first signal, said second device having nominally synchronised said second signal to the timebase using a nominal value for the propagation delay of said first signal from said first device to said second device, wherein said first device is configured to:

receive said second signal, receive said first signal via a feedback loop and interpret said second signal and said first signal;

measure a time difference between the received first signal and the received second signal, from which said time residual can be calculated; and

transmit the measured time difference or related quantity, such that said time residual can be corrected or compensated for.

In preferred embodiments the second device is configured to utilise the measured time difference or related quantity to adjust the generation of the second signal, thereby improving the accuracy of the synchronisation of the second signal to the timebase.

In other embodiments the apparatus comprises a third device configured to utilise the measured time difference or related quantity to apply a correction to signals received from the second device.

In certain embodiments the first device is configured to, after the second device has adjusted the generation of the second signal:

receive and interpret the second signal and the first signal;

measure a phase or time difference between the received and interpreted first and second signals; and

transmit the measured phase or time difference or a related quantity,

such that the second device can adjust the generation of the second signal to mitigate the effect on the synchronisation of the second signal to the timebase of environment-related variations in the propagation of the first signal.

According to a fifth aspect of the present invention there is provided, in an apparatus in which a second device generating and transmitting a second signal has synchronised said second signal to the timebase of a first device using a first signal generated and transmitted by said first device, a method for mitigating the effect on the synchronisation of environment-related variations in the propagation of said first signal, said method comprising the steps of:

(i) said first device receiving said second signal, receiving said first signal via a feedback loop and interpreting said second signal and said first signal;

(ii) said first device measuring a phase or time difference between the received and interpreted first and second signals;

(iii) said first device transmitting the measured phase or time difference or a related quantity; and

(iv) said second device adjusting the generation of said second signal according to the measured phase or time difference or the related quantity, such that the synchronisation of said second signal to said timebase is maintained.

According to a sixth aspect of the present invention there is provided an apparatus for mitigating the effect, on the synchronisation of a second signal generated and transmitted by a second device to the timebase of a first device generating and transmitting a first signal, of environment-related variations in the propagation of said first signal, wherein said first device is configured to:

receive said second signal, receive said first signal via a feedback loop and interpret said second signal and said first signal;

measure a phase or time difference between the received and interpreted first and second signals; and

transmit the measured phase or time difference or a related quantity;

and said second device is configured to:

adjust the generation of said second signal according to the measured phase or time difference or the related quantity, such that the synchronisation of said second signal to said timebase is maintained.

According to a seventh aspect of the present invention there is provided a method for determining the position of a roving position receiver in a location network comprising a reference device having a timebase, and a plurality of positioning-unit devices generating and transmitting positioning signals synchronised to the timebase of said reference device, wherein at least one of said positioning-unit devices synchronises its positioning signal to said timebase by:

(i) said reference device generating and transmitting a reference signal comprising first time information indicating the time of transmission of said reference signal according to said timebase;

(ii) said positioning-unit device:

(a) receiving and interpreting said reference signal;

(b) generating and transmitting said positioning signal comprising second time information indicating the time of transmission of said positioning signal;

(c) receiving said positioning signal via a feedback loop and interpreting said positioning signal;

(d) calculating a first time difference between said first time information and said second time information; and

(e) adjusting the generation of said positioning signal according to said first time difference, thereby adjusting said positioning signal and said second time information;

(iii) said reference device:

(a) receiving said reference signal via a feedback loop, receiving the adjusted positioning signal and interpreting said reference signal and said adjusted positioning signal;

(b) calculating a second time difference between said first time information and the adjusted second time information; and

(c) transmitting said second time difference, or a quantity related thereto; and

(iv) said positioning-unit device:

(a) receiving said second time difference or the related quantity and obtaining therefrom a measure of the propagation delay of said reference signal; and

(b) adjusting the generation of said positioning signal according to said measure of said propagation delay, thereby synchronising said positioning signal to the timebase of said reference device,

and wherein said roving position receiver calculates a position solution using a selection of positioning signals received from said plurality of positioning-unit devices, including the positioning signal received from the at least one positioning-unit device.

According to an eighth aspect of the present invention there is provided a location network for enabling a roving position receiver to calculate a position solution, said location network comprising:

a reference device configured to generate and transmit a reference signal comprising time information indicating the time of transmission of said reference signal according to a timebase of said reference device; and

a plurality of positioning-unit devices generating and transmitting positioning signals synchronised to the timebase of said reference device, wherein at least one of said positioning-unit devices is configured to:

receive and interpret said reference signal;

generate and transmit a positioning signal comprising second time information indicating the time of transmission of said positioning signal;

receive said positioning signal via a feedback loop and interpret said positioning signal;

calculate a first time difference between said first time information and said second time information; and

adjust the generation of said positioning signal according to said first time difference, thereby adjusting said positioning signal and said second time information;

and wherein said reference device is configured to:

receive said reference signal via a feedback loop, receive the adjusted positioning signal and interpret said reference signal and said adjusted positioning signal;

calculate a second time difference between said first time information and the adjusted second time information; and

transmit said second time difference or a quantity related thereto;

and wherein the at least one positioning-unit device is configured to:

receive said second time difference or the related quantity and obtain therefrom a measure of the propagation delay of said reference signal; and

adjust the generation of said positioning signal according to said measure of said propagation delay, thereby synchronising said positioning signal to the timebase of said reference device,

such that a roving position receiver is able to calculate a position solution using a selection of positioning signals received from said plurality of positioning-unit devices, including the positioning signal received from the at least one positioning-unit device.

According to a ninth aspect of the present invention there is provided an article of manufacture comprising a non-transitory computer useable medium having a computer readable program code configured to conduct the method according to the first, second, fifth or seventh aspects, or to operate the apparatus according to the third, fourth or sixth aspects, or to operate the location network according to the eighth aspect.

Brief Description of the Drawings

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

Fig 1 illustrates in schematic form an apparatus for synchronising the signal of a positioning-unit device or slave device to the timebase of a reference device, according to an embodiment of the invention;

Fig 2 shows a flowchart depicting a method for synchronising the signal of a positioning-unit device or slave device to the timebase of a reference device, according to an embodiment of the invention;

Fig 3 illustrates in schematic form an apparatus for synchronising the signal of a positioning-unit device or slave device to the timebase of a reference device, according to an embodiment of the invention;

Fig 4 shows in schematic form selected components of an apparatus in which a slave device transfers a timebase received from a reference device to a further slave device, using fixed line links;

Fig 5 shows in schematic form an apparatus in which a timebase transferred from a reference device to a slave device over a fixed line can be disseminated wirelessly to one or more other devices remote from the reference device;

What is claimed is:

1. A method for synchronising a second signal generated and transmitted by a second device to a timebase of a first device, said method comprising the steps of:

(i) said first device generating and transmitting a first signal comprising first time information indicating the time of transmission of said first signal according to the timebase of said first device;

(ii) said second device:

(a) receiving and interpreting said first signal;

(b) generating and transmitting said second signal comprising second time information indicating the time of transmission of said second signal;

(c) receiving said second signal via a feedback loop and interpreting said second signal;

(d) calculating a first time difference between said first time information and said second time information; and

(e) adjusting the generation of said second signal according to said first time difference, thereby adjusting said second signal and said second time information;

(iii) said first device:

(a) receiving said first signal via a feedback loop, receiving the adjusted second signal and interpreting said first signal and said adjusted second signal;

(b) calculating a second time difference between said first time information and the adjusted second time information; and

(c) transmitting said second time difference, or a quantity related thereto; and

(iv) said second device:

(a) receiving said second time difference or the related quantity and obtaining therefrom a measure of the propagation delay of said first signal; and

(b) adjusting the generation of said second signal according to said measure of said propagation delay,

thereby synchronising said second signal to said timebase.

2. The method according to claim 1, wherein step (ii) (e) comprises adjusting the generation of said second signal so as to minimise the difference between the first time information and the second time information.

3. The method according to claim 1 or claim 2, further comprising the steps of said first device after said second signal has been synchronised to said timebase:

receiving and interpreting said second signal and said first signal;

measuring a phase or time difference between the received and interpreted first and second signals; and

transmitting the measured phase or time difference or a related quantity,

such that said second device can adjust the generation of said second signal to mitigate the effect on the synchronisation of said second signal to said timebase of environment-related variations in the propagation of said first signal.

4. The method according to claim 3, wherein said second device adjusts the generation of said second signal according to the measured phase or time difference or related quantity.

5. The method according to any one of claims 1 to 4, wherein said first and second signals are transmitted between said first and second devices via a fixed line.

6. The method according to claim 5, wherein said fixed line comprises a coaxial cable or an optical fibre.

7. The method according to claim 5 or claim 6, further comprising the step of broadcasting, from a transmitter operatively associated with said second device, a third signal that is synchronised with said timebase.

8. In an apparatus in which a second device generating and transmitting a second signal has nominally synchronised said second signal to the timebase of a first device generating and transmitting a first signal, using a nominal value for the propagation delay of said first signal from said first device to said second device, a method for identifying a time residual between said second signal and said timebase, said method comprising the steps of said first device:

a) receiving said first signal via a feedback loop, receiving said second signal and interpreting said first signal and said second signal;

b) measuring a time difference between the received first signal and the received second signal, from which said time residual can be calculated; and

c) transmitting the measured time difference or a related quantity, such that said time residual can be corrected or compensated for.

9. The method according to claim 8, wherein said second device utilises the measured time difference or related quantity to adjust the generation of said second signal, thereby improving the accuracy of the synchronisation of said second signal to said timebase.

10. The method according to claim 8, wherein a third device utilises the measured time difference or related quantity to apply a correction to signals received from said second device.

11. The method according to claim 9, further comprising the steps of said first device after said second device has adjusted the generation of said second signal:

receiving and interpreting said second signal and said first signal;

measuring a phase or time difference between the received and interpreted first and second signals; and

transmitting the measured phase or time difference or a related quantity,

such that said second device can adjust the generation of said second signal to mitigate the effect on the synchronisation of said second signal to said timebase of environment-related variations in the propagation of said first signal.

12. A system for synchronising a second signal generated and transmitted by a second device to a timebase of a first device, said system comprising:

a first device configured to generate and transmit a first signal comprising first time information indicating the time of transmission of said first signal according to a timebase of said first device; and

a second device configured to:

receive and interpret said first signal;

generate and transmit a second signal comprising second time information indicating the time of transmission of said second signal;

receive said second signal via a feedback loop and interpret said second signal;

calculate a first time difference between said first time information and said second time information; and

adjust the generation of said second signal according to said first time difference, thereby adjusting said second signal and said second time information;

wherein said first device is further configured to:

receive said first signal via a feedback loop, receive the adjusted second signal and interpret said first signal and said adjusted second signal;

calculate a second time difference between said first time information and the adjusted second time information; and

transmit said second time difference, or a quantity related thereto;

and wherein said second device is further configured to:

receive said second time difference or the related quantity and obtain therefrom a measure of the propagation delay of said first signal; and

adjust the generation of said second signal according to said measure of said propagation delay,

thereby synchronising said second signal to said timebase.

13. The system according to claim 12, wherein said second device is configured to adjust the generation of said second signal according to said first time difference so as to minimise the difference between the first time information and the second time information.

14. The system according to claim 12 or claim 13, wherein said first device is configured to, after said second signal has been synchronised to said timebase:

receive and interpret said second signal and said first signal;

measure a phase or time difference between the received and interpreted first and second signals; and

transmit the measured phase or time difference or a related quantity,

such that said second device can adjust the generation of said second signal to mitigate the effect on the synchronisation of said second signal to said timebase of environment-related variations in the propagation of said first signal.

15. The system according to claim 14, wherein said second device is configured to adjust the generation of said second signal according to the measured phase or time difference or related quantity.

16. The system according to any one of claims 12 to 15, wherein said first and second devices are configured to transmit and receive said first and second signals via a fixed line connecting said first and second devices.

17. The system according to claim 16, wherein said fixed line comprises a coaxial cable or an optical fibre.

18. The system according to claim 16 or claim 17, further comprising a transmitter operatively associated with said second device, for broadcasting a third signal that is synchronised with said timebase.

19. An apparatus for identifying a time residual between a second signal generated and transmitted by a second device and a timebase of a first device generating and transmitting a first signal, said second device having nominally synchronised said second signal to the timebase using a nominal value for the propagation delay of said first signal from said first device to said second device, wherein said first device is configured to:

receive said second signal, receive said first signal via a feedback loop and interpret said second signal and said first signal;

measure a time difference between the received first signal and the received second signal, from which said time residual can be calculated; and

transmit the measured time difference or related quantity, such that said time residual can be corrected or compensated for.

20. The apparatus according to claim 19, wherein said second device is configured to utilise said measured time difference or related quantity to adjust the generation of said second signal, thereby improving the accuracy of the synchronisation of said second signal to said timebase.

21. The apparatus according to claim 19, wherein said apparatus comprises a third device configured to utilise said measured time difference or related quantity to apply a correction to signals received from said second device.

22. The apparatus according to claim 20, wherein said first device is configured to, after said second device has adjusted the generation of said second signal:

receive and interpret said second signal and said first signal;

measure a phase or time difference between the received and interpreted first and second signals; and

transmit the measured phase or time difference or a related quantity,

such that said second device can adjust the generation of said second signal to mitigate the effect on the synchronisation of said second signal to said timebase of environment-related variations in the propagation of said first signal.

23. In an apparatus in which a second device generating and transmitting a second signal has synchronised said second signal to the timebase of a first device using a first signal generated and transmitted by said first device, a method for mitigating the effect on the synchronisation of environment-related variations in the propagation of said first signal, said method comprising the steps of:

(i) said first device receiving said second signal, receiving said first signal via a feedback loop and interpreting said second signal and said first signal;

(ii) said first device measuring a phase or time difference between the received and interpreted first and second signals;

(iii) said first device transmitting the measured phase or time difference or a related quantity; and

(iv) said second device adjusting the generation of said second signal according to the measured phase or time difference or the related quantity, such that the synchronisation of said second signal to said timebase is maintained.

24. An apparatus for mitigating the effect, on the synchronisation of a second signal generated and transmitted by a second device to the timebase of a first device generating and transmitting a first signal, of environment-related variations in the propagation of said first signal, wherein said first device is configured to:

receive said second signal, receive said first signal via a feedback loop and interpret said second signal and said first signal;

measure a phase or time difference between the received and interpreted first and second signals; and

transmit the measured phase or time difference or a related quantity;

and said second device is configured to:

adjust the generation of said second signal according to the measured phase or time difference or the related quantity, such that the synchronisation of said second signal to said timebase is maintained.

25. A method for determining the position of a roving position receiver in a location network comprising a reference device having a timebase, and a plurality of positioning-unit devices generating and transmitting positioning signals synchronised to the timebase of said reference device, wherein at least one of said positioning-unit devices synchronises its positioning signal to said timebase by:

(i) said reference device generating and transmitting a reference signal comprising first time information indicating the time of transmission of said reference signal according to said timebase;

(ii) said positioning-unit device:

(a) receiving and interpreting said reference signal;

(b) generating and transmitting said positioning signal comprising second time information indicating the time of transmission of said positioning signal;

(c) receiving said positioning signal via a feedback loop and interpreting said positioning signal;

(d) calculating a first time difference between said first time information and said second time information; and

(e) adjusting the generation of said positioning signal according to said first time difference, thereby adjusting said positioning signal and said second time information;

(iii) said reference device:

(a) receiving said reference signal via a feedback loop, receiving the adjusted positioning signal and interpreting said reference signal and said adjusted positioning signal;

(b) calculating a second time difference between said first time information and the adjusted second time information; and

(c) transmitting said second time difference, or a quantity related thereto; and

(iv) said positioning-unit device:

(a) receiving said second time difference or the related quantity and obtaining therefrom a measure of the propagation delay of said reference signal; and

(b) adjusting the generation of said positioning signal according to said measure of said propagation delay, thereby synchronising said positioning signal to the timebase of said reference device,

and wherein said roving position receiver calculates a position solution using a selection of positioning signals received from said plurality of positioning-unit devices, including the positioning signal received from the at least one positioning-unit device.

26. A location network for enabling a roving position receiver to calculate a position solution, said location network comprising:

a reference device configured to generate and transmit a reference signal comprising first time information indicating the time of transmission of said reference signal according to a timebase of said reference device; and

a plurality of positioning-unit devices generating and transmitting positioning signals synchronised to the timebase of said reference device, wherein at least one of said positioning-unit devices is configured to:

receive and interpret said reference signal;

generate and transmit a positioning signal comprising second time information indicating the time of transmission of said positioning signal;

receive said positioning signal via a feedback loop and interpret said positioning signal;

calculate a first time difference between said first time information and said second time information; and

adjust the generation of said positioning signal according to said first time difference, thereby adjusting said positioning signal and said second time information;

and wherein said reference device is configured to:

receive said reference signal via a feedback loop, receive the adjusted positioning signal and interpret said reference signal and said adjusted positioning signal;

calculate a second time difference between said first time information and the adjusted second time information; and

transmit said second time difference or a quantity related thereto;

and wherein the at least one positioning-unit device is configured to:

receive said second time difference or the related quantity and obtain therefrom a measure of the propagation delay of said reference signal; and

adjust the generation of said positioning signal according to said measure of said propagation delay, thereby synchronising said positioning signal to the timebase of said reference device,

such that a roving position receiver is able to calculate a position solution using a selection of positioning signals received from said plurality of positioning-unit devices, including the positioning signal received from the at least one positioning-unit device.

27. An article of manufacture comprising a non-transitory computer useable medium having a computer readable program code configured to conduct the method according to any one of claims 1 to 11, 23 and 25, or to operate the apparatus according to any one of claims 12 to 22 and 24, or to operate the location network according to claim 26.