CLAIMS

What is claimed is:

1. A method, comprising:

transmitting, from at least two vehicle beacons on a first vehicle, a ranging signal to at least two external beacons;

receiving, at the at least two vehicle beacons, a return signal from the at least two external beacons; and

determining, based on the return signal from the at least two external beacons, a position of each of the external beacons with respect to the at least two vehicle beacons of the first vehicle.

2. The method of claim 1, wherein determining the position of each of the external beacons with respect to the at least two vehicle beacons of the first vehicle comprises determining whether the at least two external beacons are associated with a second vehicle on a same track as the first vehicle.

3. The method of claim 1, wherein determining the position of each of the external beacons with respect to the at least two vehicle beacons of the first vehicle comprises determining whether the at least two external beacons are associated with a second vehicle on a different track from the first vehicle.

4. The method of claim 1, wherein determining the position of each of the external beacons with respect to the at least two vehicle beacons of the first vehicle comprises determining whether the at least two external beacons are associated with a track below the first vehicle.

5. The method of claim 2, wherein determining whether the at least two external beacons are associated with the second vehicle on the same track as the first vehicle comprises determining a separation distance between the first vehicle and the second vehicle.

6. The method of claim 5, wherein transmitting, from at least two vehicle beacons on the first vehicle, the ranging signal to at least two external beacons comprises:

transmitting, from a first beacon of the at least two vehicle beacons on the first vehicle, a first ranging signal to a first and a second external beacon of the at least two external beacons on the second vehicle, and

transmitting, from a second beacon of the at least two vehicle beacons on the first vehicle, a second ranging signal to the first and the second external beacon of the at least two external beacons on the second vehicle, and

determining the separation distance between the first vehicle and the second vehicle comprises:

receiving, at the first and the second beacon of the at least two vehicle beacons on the first vehicle, a first return signal from the first external beacon of the at least two external beacons, and

receiving, at the first and the second beacon of the at least two vehicle beacons on the first vehicle, a second return signal from the second external beacon of the at least two external beacons.

7. The method of claim 6, further comprising determining an inter-beacon distance based on the first return signal and the second return signal received by comparing a signal transit time for each of the first return signal and the second return signal at the first and the second beacon of the at least two vehicle beacons on the first vehicle.

8. A method, comprising:

measuring an inter-beacon distance for each beacon on a first vehicle, with respect to a set of beacons on a second vehicle;

calculating an inter-vehicle distance based on the inter-beacon distance from the first vehicle to the second vehicle;

comparing the calculated inter-vehicle distance, and the measured inter-beacon distances, to a set of vehicle configuration models;

calculating, based on the vehicle configuration models, a modeled value of the inter-beacon distances;

determining whether the measured and calculated inter-beacon distances converge; and

performing a safety operation based on the determination.

9. The method of claim 8, further comprising adjusting an inter-track separation distance before calculating the modeled value of the inter-beacon distances.

10. The method of claim 8, wherein the safety operation further comprises applying brakes of the first vehicle.

11. The method of claim 8, further comprising determining whether the first vehicle and the second vehicle are on a same track.

12. The method of claim 11, further comprising determining that the first vehicle and the second vehicle are not on the same track, and incrementing an inter-track separation distance in response to the determination that the first vehicle and the second vehicle are not on the same track.

13. The method of claim 8, wherein the safety operation further comprises transmitting to the second vehicle, information related to a second vehicle position.

14. A system for calculating vehicle position, comprising

a set of first beacons on a first vehicle, each first beacon on the first vehicle configured to transmit a coded pulse;

a set of second beacons external to the first vehicle, the second beacons configured to receive the coded pulse and to transmit a reply pulse;

an obstacle avoidance computer of the first vehicle, configured to receive the reply pulse and determine inter-beacon distances between the beacons of the set of first beacons and the set of second beacons, and calculating a position of the first vehicle in response to the reply pulse.

15. The system of claim 14, wherein the obstacle avoidance computer of the first vehicle is further configured to initiate a safety operation based on the position of the first vehicle calculated from the reply pulse.

16. The system of claim 14, further comprising a second vehicle obstacle avoidance computer configured to calculate a second vehicle position based on a time-of-flight measurement based on the coded pulse from the first beacons.

17. The system of claim 16, wherein the second vehicle obstacle avoidance computer is further configured to initiate motion of ~~the~~ a second vehicle upon determining the second vehicle position.

18. The system of claim 17, wherein the second vehicle obstacle avoidance computer is further configured to cause the second beacons to transmit coded pulses to external beacons not on the first vehicle or the second vehicle, and receive response pulses from the external beacons, and refine the second vehicle position based on a time-of-flight measurement based on the response pulses from the external beacons.

19. The system of claim 17, wherein the second beacons are configured to include the coded pulse in the reply pulse before transmitting the reply pulse.

20. The system of claim 17, further comprising a range-finding system to perform an inter-vehicle distance measurement for the obstacle avoidance computer of the first vehicle.