

CLAIMS

1. A method of determining a safe speed for a train comprising:
 determining a current location of the train on a railway;
 determining a detection range of a sensor system of the train based on the current
 5 location of the train and a data store comprising information from which the detection
 range at a plurality of locations on the railway can be determined; and
 determining a safe speed for the train based on the detection range.
2. The method of claim 1 wherein determining the safe speed comprises determining a first
 10 speed at which a braking distance of the train is within the detection range and setting
 said first speed as the safe speed.
3. The method of claim 1 or 2 further comprising at least one of: displaying the safe speed,
 generating an alert if a current speed of the train is greater than the safe speed or
 adjusting a current speed of the train if the current speed is greater than the safe speed.
4. The method of any of the above claims wherein the data store is a digital map
 15 comprising information relating to a geometry of the railway tracks including track slope
 and track curvature.
5. The method of claim 4 wherein determining the detection range of the train comprises
 performing a calculation in real time to determine the detection range based on the
 geometry of the railway tracks in upcoming sections of the railway along a route of the
 20 train ahead of the current location of the train.
6. The method of claim 5 wherein the calculation comprises determining from the digital
 map whether the upcoming sections of the railway include straight, curved, level,
 upwardly inclined or downwardly inclined sections.
7. The method of claim 5 wherein the calculation comprises:
 25 determining whether the upcoming sections include a curved or sloped section;
 setting the detection range as a first predetermined distance X in response to
 determining that the upcoming sections do not include a curved or sloped section;
 calculating the detection range based at least in part on a radius of the curved section in
 response to determining the upcoming sections include a curved section; and

calculating the detection range based at least in part on a gradient of the slope in response to determining the upcoming sections include a sloped section.

8. The method of claim 7 wherein calculating the detection range includes smoothing the variation of detection range so that the detection range decreases gradually from the first predetermined distance X to a second distance Y and gradually increases from the second distance Y to the first predetermined distance X, wherein X is a detection range for a flat, straight section of railway track and Y is a minimum detection range in relation to a curved or sloped section of the railway track.
9. The method of claim 8 comprising gradually decreasing the detection range from X to Y at locations approaching the start of the curved section and gradually increasing the detection range from Y to X at locations approaching the end of the curved section; wherein Y is a minimum detection range for the curved section.
10. The method of claim 8 wherein the minimum detection range Y is applied at locations between a first distance Z and a second distance W ahead of a junction between two portions of the sloped section having different gradients, Z and W being calculated based on characteristics of the sloped section.
11. The method of any one of the above claims comprising the sensor system identifying an obstacle on the rail track ahead of the train and determining the safe speed of the train based on the detected obstacle.
12. The method of any one of the above claims wherein the sensor system comprises a camera and Laser Detecting and Ranging (LiDAR) apparatus and wherein determining the location of the train comprises identifying a location on the digital map having features which match features detected by the camera and LiDAR apparatus.
13. An on-board system for a train comprising:
 - a sensor system for detecting objects on a railway track ahead of the train;
 - a locating system for determining a current location of the train;
 - a data store comprising information from which detection ranges of the sensor system at a plurality of locations on the railway can be determined; and
 - a speed determining module configured to:
 - receive a current location of the train from the locating system;

determine a detection range of the sensor system based on the current location of the train and the information in the data store; and

determine a safe speed for the train based on the determined detection range of the sensor system.

- 5 14. The on-board system of claim 13 wherein the on-board system is configured to perform the method of any one of claims 1-12 or 17-22.
- 10 15. The on-board system of claim 13 or 14 wherein the sensor system comprises a camera and a Laser Detection and Ranging (LiDAR) apparatus and the locating system is configured to determine a location of the train by comparing landmarks in a digital map with landmarks detected by the camera and LiDAR apparatus.
- 15 16. The on-board system of claim 13 or 14 wherein the on-board system comprises:
a camera for generating a video stream comprising a plurality of 2D images;
a visual analytics module for detecting objects in the 2D images of the video stream;
a LiDAR apparatus for generating a 3D point cloud;
an integration module for integrating data from the visual analytics module with data from the point cloud generated by the LiDAR apparatus to form a digital model of an environment of the train; and
wherein the locating system is configured to match the digital model with a location on the digital map.
- 20 17. A method of determining a location of a train on a railway comprising:
receiving a video stream of an environment of the train from a camera mounted on the train;
receiving Light Detection and Ranging (LiDAR) data of an environment of the train generated by a LiDAR system mounted on the train;
25 generating a digital model of an environment of the train based on the video stream and the LiDAR data;
detecting a landmark in the digital model having identifying features which correspond with identifying features of a landmark having a known location in a digital map of the railway;

determining a speed of the train; and

determining a current location of the train based on the known location of the landmark, the speed of the train and the time elapsed since the landmark was detected.

18. The method of claim 17 comprising detecting a second landmark in the digital model and performing a location calibration in response to detecting the second landmark.
19. The method of claim 18 wherein location calibration comprises re-setting the current location to the location of the second landmark.
20. The method of claim 18 comprising detecting a difference between the determined current location and a known location of the second landmark and adjusting the determining of a current location to correct for this difference.
21. The method of any one of claims 17 to 20 wherein generating the digital model comprises combining information from a visual analytics system which detects objects in 2D images of the video stream with information on objects from a 3D point cloud generated based on the LiDAR data.
22. The method of any one of claims 17 to 21 wherein the landmark is a station or trackside infrastructure.
23. An on-board system for a train comprising:
 - a camera to generate a video stream of an environment of the train,
 - a LiDAR system to generate LiDAR data of an environment of the train;
 - a digital map comprising identifying features and known locations of a plurality of landmarks of the railway;
 - a landmark detection module to detect a landmark in the video stream and the LiDAR data having features which match identifying features of a landmark in the digital map;
 - a speed determining apparatus to determine a speed of the train;
 - a location determining module to determine a current location of the train based on the known location of the detected landmark, the speed of the train and a time elapsed since the landmark was detected.
24. The on-board system of claim 23 wherein the on-board system is configured to carry out the method of any one of claims 1-12 or 17-22.

25. The on-board system of claim 23 or 24 wherein the speed determining apparatus is a radar or LiDAR speed sensor.
26. The method of claim 11, wherein the detected obstacle is a buffer stop.