CLAIMS

1. A standalone odometry device comprising:

a first dual axis accelerometer mounted on a first wheel or axle of a vehicle;

a second dual axis accelerometer mounted on a second wheel or axle of a vehicle;

a third dual axis accelerometer mounted on a third wheel or axle of a vehicle;

a fourth dual axis accelerometer mounted on a fourth wheel or axle of a vehicle; wherein the first dual axis accelerometer, the second dual axis accelerometer, the third dual axis accelerometer and the fourth dual axis accelerometer are arranged in a 90º out-of-phase arrangement; and

a controller in communication with the first dual axis accelerometer, the second dual axis accelerometer, the third dual axis accelerometer and the fourth dual axis accelerometer and configured to receive data from the first dual axis accelerometer, the second dual axis accelerometer, the third dual axis accelerometer and the fourth dual axis accelerometer, the controller processes the data to determine one or more of the speed, wheel rotation direction, accumulated distance travelled, stationary status, acceleration, deceleration, wheel diameter, and grade of surface on which the wheel is in contact with.

2. The device of claim 1, wherein the one or more equations comprise:

Equation (1) $a_c = \omega^2 r + g\cos\theta_{Grade}\cos\theta - a_{M/B}\sin\theta - a_V\cos\theta$, wherein a_c = centripetal acceleration measured by an accelerometer, ω = wheel/axle angular speed, r = distance from a wheel/axle centre to a sensor, g = gravity, $a_{M/B}$ = net acceleration due to motoring & braking (compensated for the wheel to rail friction and drag along the vehicle's primary axis), a_V = acceleration due to vibration, train dynamics and other sources perpendicular to a vehicle's primary axis, θ = accelerometer angular position on a wheel/Axle, and θ_{Grade} = angular slope due to grade at a wheel-rail contact point.

3. The device of claim 1, wherein the one or more equations comprise:

Equation (2) $V = r_{Wheel}\omega = r_{Wheel}((a_c + a_{M/B}\sin\theta + a_V\cos\theta - g\cos\theta_{Grade}\cos\theta) / r)^{½}$, wherein V = vehicle's translation speed, r_{Wheel} = wheel radii, a_c = centripetal acceleration measured by an

accelerometer, $a_{M/B}$ = net acceleration due to motoring & braking (compensated for a wheel to rail friction and drag along a vehicle's primary axis), a_V = acceleration due to vibration, and θ = accelerometer angular position on a wheel/axle.

4. The device of claim 1, wherein the one or more equations comprise:

Equation (3) $\theta = \theta_0 + \omega t + \frac{1}{2}\alpha t^2$, wherein θ = accelerometer angular position on the wheel/axle, ω = wheel/axle angular speed, t = time, and α = wheel/axle angular acceleration.

5. The device of claim 1, wherein the one or more equations comprise:

Equation (4) $V = r_{Wheel}\,\omega = r_{Wheel}((a_{c1} + a_{c2}) / (r_1 + r_2))^{\frac{1}{2}}$, wherein V = vehicle's translation speed, r_{Wheel} = wheel radii, ω = wheel/axle angular speed, a_{c1} = centripetal acceleration measured by the first dual axis accelerometer and a_{c2} = centripetal acceleration measured by the second dual axis accelerometer, r_1 is the distance from a wheel/axle centre to a first sensor and r_2 is the distance from a wheel/axle centre to a second sensor.

6. The device of claim 1, wherein the one or more equations comprise:

Equation (5) $a_t = \alpha r + g\cos\theta_{Grade}\sin\theta + a_{M/B}\cos\theta - a_V\sin\theta$, wherein a_t = tangential acceleration, α = angular acceleration, r = distance from wheel axle centre to a sensor, g = gravity, θ_{Grade} = grade acceleration, θ = accelerometer angular position on a wheel/axle, $a_{M/B}$ = acceleration due to motoring and braking, and a_V = acceleration due to vibration, train dynamics and other sources perpendicular to a vehicle's primary axis.

7. The device of claim 1, wherein the one or more equations comprise:

Equation (6) $\theta_{Grade} = \cos^{-1}(A\cos\theta + B) / (g(\sin\theta + \cos^2\theta))$, where, $A = (r_2(a_{c1} + a_{t3}) - r_1(a_{c2} + a_{t1} + a_{t2} - a_{t3})) / (2(r_1 + r_2)$ and $B = (r_2(a_{t1} - a_{c3}) - r_1(a_{t2} + a_{c3} - a_{c1} - a_{c2})) / (2(r_1 + r_2))$, wherein θ_{Grade} = angular slope due to grade at a wheel-rail contact point, θ = accelerometer angular position on a wheel/axle, r = distance from a wheel/axle centre to a sensor, a_t = tangential acceleration and a_c = centripetal acceleration measured by an accelerometer.

8. The device of claim 1, wherein the one or more equations comprise:

Equation (7) $a_{M/B} = g\cos\theta_{Grade}\cos\theta - A$ where $A = (r_2(a_{c1} + a_{t3}) - r_1(a_{c2} + a_{t1} + a_{t2} - a_{t3})) / (2(r_1 + r_2)$, wherein $a_{M/B}$ = acceleration due to motoring and braking, g = gravity, θ_{Grade} = angular slope due to grade at a wheel-rail contact point, θ = accelerometer angular position on a wheel/axle, r = distance from a wheel/axle centre to a sensor, a_t = tangential acceleration and a_c = centripetal acceleration measured by an accelerometer.

9. The device of claim 1, wherein the one or more equations comprise:

Equation (8) $\alpha = (a_{t1} + a_{t2}) / (r_1 + r_2) = (a_{t3} + a_{t4}) / (r_1 + r_2)$, wherein α = angular acceleration, r = distance from a wheel/axle centre to a sensor, and a_t = tangential acceleration.

10. The device of claim 1, wherein the one or more equations comprise:

Equation (9) $\omega^2 = (a_{c1} + a_{c2}) / (r_1 + r_2) = (a_{c3} + a_{c4}) / (r_1 + r_2)$, wherein ω = wheel/axle angular speed, r = distance from a wheel/axle centre to a sensor, and a_c = centripetal acceleration measured by an accelerometer.

11. The device of claim 1, wherein the one or more equations comprise:

Equation (10) $a_{M/B} + g\sin\theta_{Grade} = r_{Wheel}\alpha$,wherein $a_{M/B}$ = acceleration due to motoring and braking, g = gravity, θ_{Grade} = angular slope due to grade at a wheel-rail contact point, r_{Wheel} = wheel radii and α = angular acceleration.

12. The device of claim 1, wherein the one or more equations comprise:

Equation (11) $r_{Wheel} = (a_{M/B} + g\sin\theta_{Grade}) / \alpha$, wherein r_{Wheel} = wheel radii, $a_{M/B}$ = acceleration due to motoring and braking, g = gravity, θ_{Grade} = angular slope due to grade at a wheel-rail contact point and α = angular acceleration.

13. The device of claim 1, wherein the one or more equations comprise:

Equation (12) $d = \Sigma V \times \Delta t$, wherein d = accumulative distance travelled, V = vehicle's translation speed, and t = time .

14. The device of claim 1, wherein the one or more equations comprise:

Equation (13) $d = n \times 2\pi r_{Wheel} + ((\theta - \theta_0)\pi r_{Wheel} / 180)$, wherein d = accumulative distance

travelled, n = number of wheel/axle complete revolutions, θ = accelerometer angular position on a wheel/axle, and r_{Wheel} = wheel radii.

15. The device of claim 1, wherein wheel radii is monitored that it is within certain configurable bounds otherwise an alarm is raised.

16. The device of claim 1, wherein grade is monitored that it conforms within certain configurable bounds to a database grade profile, otherwise an alarm is raised.

17. The device of claim 1, wherein speed is monitored that it conforms within certain configurable bounds to an expected speed profile, otherwise an alarm is raised.

18. The device of claim 1, wherein acceleration due to motoring and braking is monitored that it conforms within certain configurable bounds to an expected acceleration profile, otherwise an alarm is raised.

19. The device of claim 1, wherein wheel/axle vibrations characteristics are determined and monitored that it is within certain configurable bounds otherwise an alarm is raised.

20. The device of claim 1, wherein wheel/axle shocks characteristics are determined and monitored that it is within certain configurable bounds otherwise an alarm is raised.