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 plurality of dual axis accelerometers, wherein the plurality of dual axis accelerometers includes a set of four dual axis accelerometers including:

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

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

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

a fourth dual axis accelerometer mounted on a fourth position of the wheel or axle of the 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 90° out-of-phase arrangement; and

a controller in communication with the four dual axis accelerometers, the controller configured to receive data from the four dual axis accelerometers and process the data to determine one or more parameters selected from a group consisting of acceleration due to motoring, deceleration due to braking, a self-calibrated wheel diameter, a grade of a surface with which the wheel is in contact, a velocity, acceleration due to the grade, and deceleration due to the grade. ~~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 controller processes the data using at least one of a plurality of equations, the plurality of equations comprising~~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) $\theta = \theta_0 + \omega t + ½\alpha t^2$,

~~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) $V = r_{Wheel}\,\omega = r_{Wheel}((a_{c1} + a_{c2}) / (r_1 + r_2))^{½}$,

~~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) $d = \Sigma V \times \Delta t$, and

~~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.~~

wherein

$A = (r_2(a_{c1} + a_{t3}) - r_1(a_{c2} + a_{t1} + a_{t2} - a_{t3})) / (2(r_1 + r_2)$,

a_c = centripetal acceleration,

a_{c1} = centripetal acceleration measured by the first dual axis accelerometer,

a_{c2} = centripetal acceleration measured by the second dual axis accelerometer,

a_{c3} = centripetal acceleration measured by the third dual axis accelerometer,

a_{c4} = centripetal acceleration measured by the fourth dual axis accelerometer,

$a_{M/B}$ = net acceleration due to motoring & braking (compensated for the wheel to rail friction and drag along a primary axis of the vehicle),

a_t = tangential acceleration,

a_{t1} = tangential acceleration measured by the first dual axis accelerometer,

a_{t2} = tangential acceleration measured by the second dual axis accelerometer,

a_{t3} = tangential acceleration measured by the third dual axis accelerometer,

a_{t4} = tangential acceleration measured by the fourth dual axis accelerometer,

a_V = acceleration due to vibration, train dynamics and other sources perpendicular to the primary axis of the vehicle,

$B = (r_2(a_{t1} - a_{c3}) - r_1(a_{t2} + a_{c3} - a_{c1} - a_{c2})) / (2(r_1 + r_2))$,

d = accumulative distance travelled,

g = gravity,

n = number of wheel/axle complete revolutions,

r = distance from a wheel/axle centre,

r_1 = distance from the wheel/axle centre to the first position of the first dual axis accelerometer,

r_2 = distance from the wheel/axle centre to the second position of the dual axis accelerometer,

r_{Wheel} = radius of the wheel or axle,

t = time,

V = vehicle's translation speed,

α = angular acceleration,

θ = accelerometer angular position on the wheel or axle,

θ_{Grade} = angular slope due to grade at a wheel-rail contact point, and

ω = wheel/axle angular speed.

~~15~~3. The device of claim 1, wherein the controller is configured for comparing the self-calibrated wheel radii to a predetermined range of wheel radii and initiating an alarm if the self-calibrated wheel radii is outside of the predetermined range. ~~wheel radii is monitored that it is within certain configurable bounds otherwise an alarm is raised.~~

~~16~~4. The device of claim 1, wherein the controller is configured for comparing the grade of a surface with which the wheel is in contact to a database grade profile and initiating an alarm if the grade of a surface with which the wheel is in contact is outside of the database grade profile.~~grade is monitored that it conforms within certain configurable bounds to a database grade profile, otherwise an alarm is raised.~~

~~17~~5. The device of claim 1, wherein the controller is configured for comparing the velocity of the vehicle with a predetermined range of velocities and initiating an alarm if the velocity of the vehicle is outside the predetermined range. ~~speed is monitored that it conforms within certain configurable bounds to an expected speed profile, otherwise an alarm is raised.~~

~~18~~6. The device of claim 1, wherein the controller is configured for comparing acceleration due to motoring and deceleration due to braking against predetermined ranges of acceleration and deceleration initiating an alarm if the acceleration due to motoring or deceleration due to braking is outside of the predetermined ranges of acceleration and deceleration. ~~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~~7. The device of claim 1, further comprising a fifth dual axis accelerometer mounted on a first static structure of the vehicle, wherein the fifth dual axis accelerometer generates a fifth signal corresponding to a linear movement of the vehicle, wherein the controller is configured to receive data from the fifth dual axis accelerometer. ~~wherein wheel/axle vibrations characteristics are determined and monitored that it is within certain configurable bounds otherwise an alarm is raised.~~

~~20~~8. The device of claim 1, further comprising:

a battery in electrical contact with each of the four dual axis accelerometers; and

a generator configured for charging the battery when the vehicle is in motion.~~wherein wheel/axle shocks characteristics are determined and monitored that it is within certain configurable bounds otherwise an alarm is raised.~~