Inertial Navigation Systems (INS)

The basic idea in an INS is to ~~integ~~ measure inertial accelerations using accelerometers & integrate ~~them~~ twice to obtain displacements from ~~some~~ the initial point.

Since accelerometers measure accelerations other than that due to gravity, the equations to be integrated are

$$\ddot{x}_i = g_i + f_i$$

where x_i - displacement w.r.t an inertial observer,

g_i - inertial components of the local gravitational accn.

f_i - inertial components of the accn. measured on board.

~~To generate~~ The inertial components of gravitational accn are obtained from a gravity model $g_i = g(x_i)$.

The inertial components of the accn. can be obtained in one of two ways.

A) Stabilized gimballed platform:

Three ~~acc~~ accelerometers are placed orthogonally on a gimballed platform. The gimbals are actuated by motors. The platform also carries angular rate gyros that measure the inertial angular velocity of the platform.

The angular velocity measurements are used to drive the gimbal motors in such a way that the platform maintains its orientation. The platform thus remains nearly inertial, & the accelerometer ~~a~~ measurements directly yield inertial components of the ~~acceleration~~ specific forces.

– Mechanically complex, expensive, weigh more.

B) Strap down system:

The accelerometers are fixed to the vehicle, & yield body components f_b of the specific forces. To convert body components f_b into inertial components f_i, the ~~atti~~ orientation of ~~the~~ body frame has to be determined. Hence, ~~along with accelerometers, rate gyros are~~ ~~s~~ the strap down system also carries rate gyros that measure the body components of the angular velocity vector $\omega_b = [p\ q\ r]$.

~~The~~ ~~orientation~~ Body components can be ~~a~~ transformed to inertial components using a 3×3 rotation matrix R, that is

$$f_I = R f_b.$$

The matrix R describes the orientation of the body frame relative to the inertial frame, & satisfies the rotational kinematics equation

$$\dot{R} = R\Omega, \quad \text{where } \Omega = \begin{bmatrix} 0 & -r & q \\ r & 0 & -p \\ -q & p & 0 \end{bmatrix}$$

Thus strapdown navigation involves integrating the following equations.

$$\dot{R} = R\Omega.$$

$$\dot{v}_i = g_i(x_i) + R f_b.$$

$$\dot{x}_i = v_i$$

An INS is thus self contained (autonomous), not subject to LOS problems, jamming, spoofing. Drawback is ~~drift caused by~~ degradation of accuracy due to sensor errors getting integrated.