Vertical Reference Units

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DP System Requirements

- GPS antenna motion compensation (roll/pitch stabilisation)
- APS motion compensation (roll/pitch/heave stabilisation)

Low Technology - Inclinometers

- Bubble or accelerometer based
- Very low cost
- Satisfactory operation in static conditions
- Errors increase with dynamics

Traditional Technology

- Fluid suspension stabilised measurement platform
- Disadvantages
  - Cost of purchase, maintenance and through-life costs; size; weight; installation difficulties; transport limitations

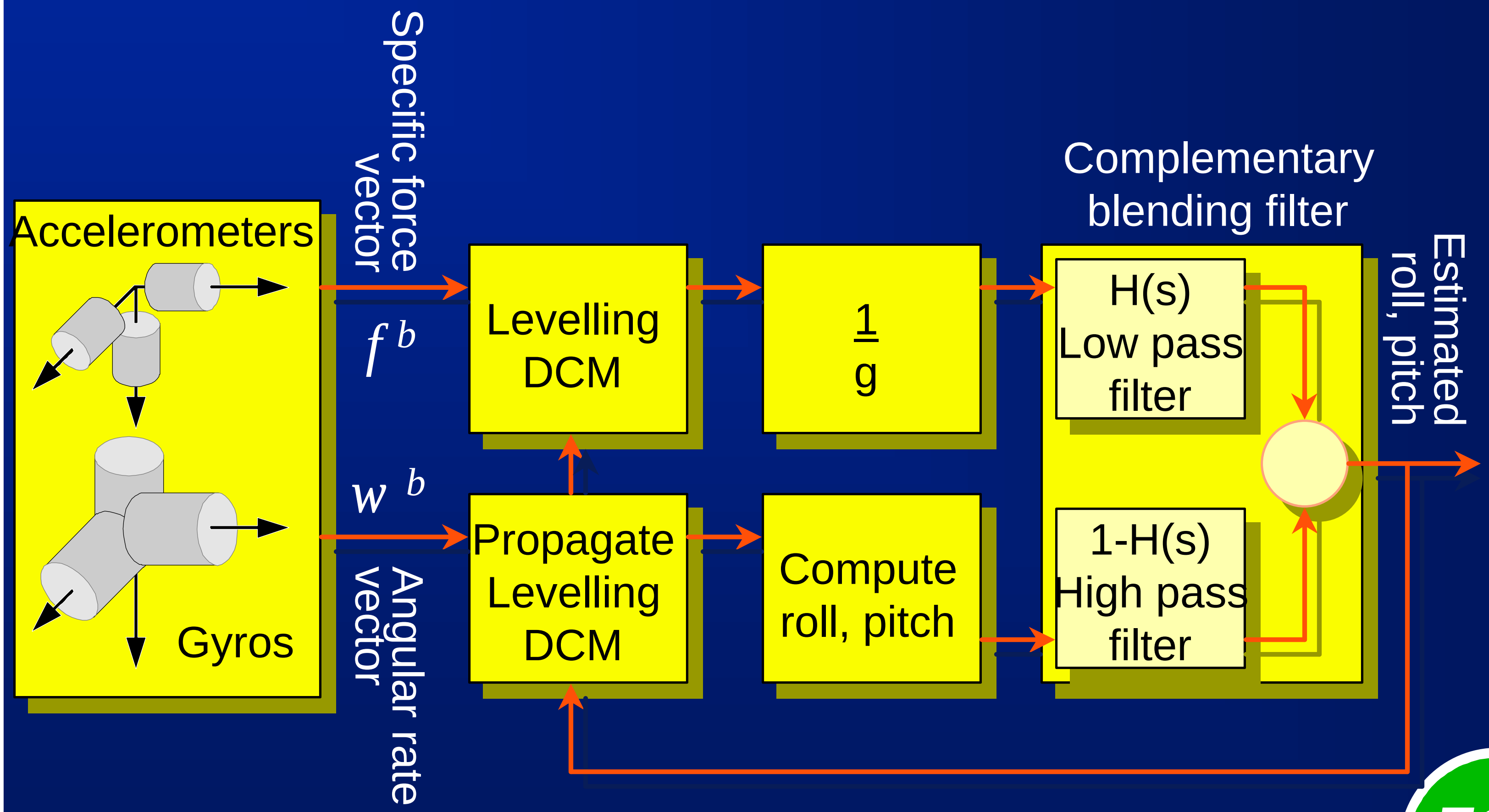
Vertical Gyros - Algorithm

Uses accelerometer outputs to determine the vertical direction as defined by the apparent vertical. If the vehicle's average acceleration is zero then the *apparent vertical* coincides with the true vertical defined by gravity.

Uses the gyros to measure the short-term roll and pitch displacements about the apparent vertical.

Complementary blending filter combines the long and short term measurements of roll and pitch to generate the estimated roll and pitch.

Vertical Gyros - Block Diagram



Vertical Gyros

Advantages

Requires no data other than from the accelerometers and gyros.

Drawbacks

Will align with the apparent vertical as defined by the low-pass filtered or averaged specific force vector. If the vessel exhibits a long-term lateral acceleration, such as during a turn, then the apparent vertical will be deflected from the true vertical.

The amount of apparent vertical deflection is controlled by the cut-off frequency of the low-pass filter. Lower cut-off frequencies extend the settling time of the apparent vertical.

Low- and high-pass filter design is a trade-off between rejection of deflections in the apparent vertical and rejection of drift errors in the gyros.

Vertical Gyros

- Low cost
- Reasonable accuracy roll, pitch and heave
- No heading information
- Good accuracy for GPS antenna stabilisation - typically ±0.25°

GPS Aided Vertical Gyros

GPS velocity information is combined with rate of turn measurements from the Sensor to determine the magnitude of centripetal acceleration.

Once calculated, the value for centripetal acceleration is used to correct the apparent vertical to align it with the true vertical.

Further gains in accuracy can be achieved by using information from a compass to provide a heading reference. This can then be used to compensate for any short-term drift in the yaw rate gyro.

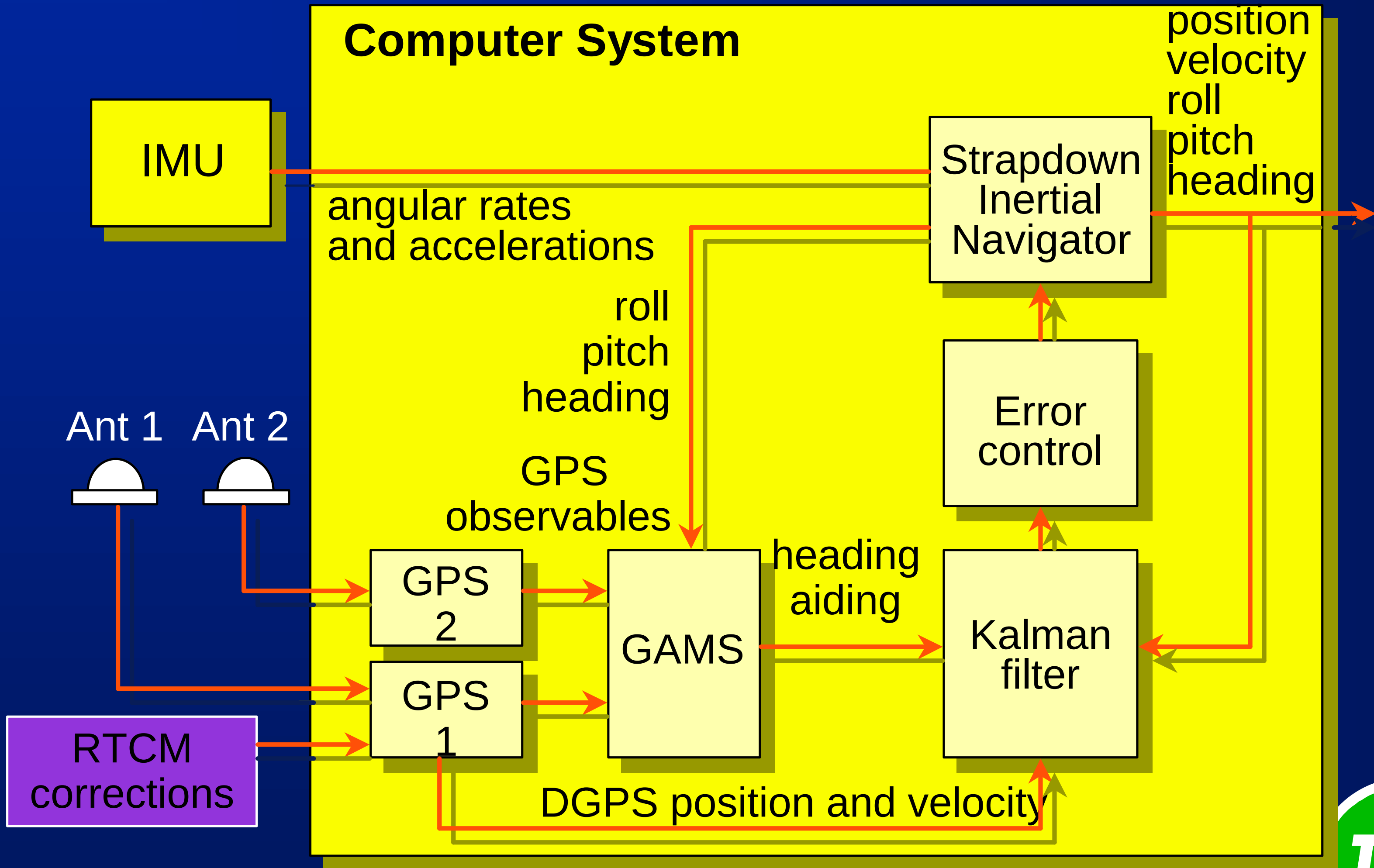
GPS Aided Vertical Gyros

- High accuracy roll, pitch and heave
- No heading information
- High accuracy for APS Stabilisation - typically ±0.05° in high dynamic conditions

GPS Aided Inertial Navigation Systems

- High accuracy position, roll, pitch, heading and heave
- Immunity to GPS outages
- Heading error less than ±0.05°
- Roll and pitch error less than ±0.05°
- High accuracy for APS stabilisation in all dynamics and all latitudes

GPS Aided INS Block Diagram



Future Developments

- High performance, compact and lower cost Vertical Gyros for antenna stabilisation
- High Accuracy GPS Aided Inertial Navigation Systems - a source of high rate, low noise, accurate position and orientation for tomorrow's DP Systems?
- Integrated systems e.g. Helideck Motion Monitoring, Crane De-rating, etc.