

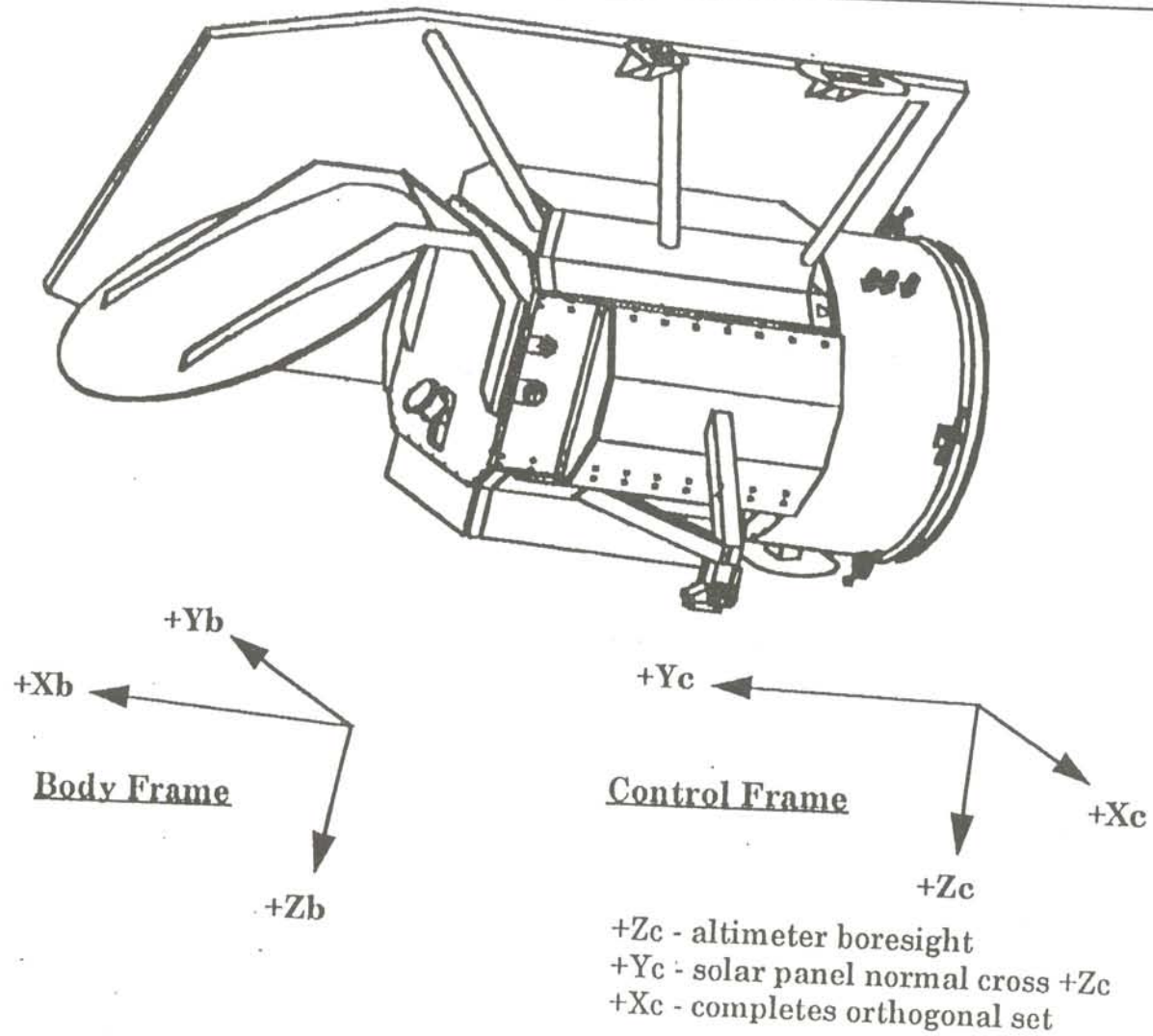


Desired Attitude State Definition is Mode-Dependent

- Detumble state
 - Zero body rates
- Acquire sun state
 - Solar panel normal aligned with measured sun vector
 - Zero body rates
- Point state
 - Altimeter boresight aligned with geodetic nadir
 - Solar-panel-normal-cross-altimeter-boresight aligned with sun-cross-geodetic-nadir
 - Modified sun vector used when $\beta < 3$ deg to improve yaw maneuver
- Acquire ΔV state and ΔV state
 - Line of thrust (\sim body frame X-axis) aligned with desired orbit adjust direction
 - Roll around thrust axis defined to align body frame Z-axis closely with nadir for horizon scanner coverage



Body Frame and Point Mode Control Frame





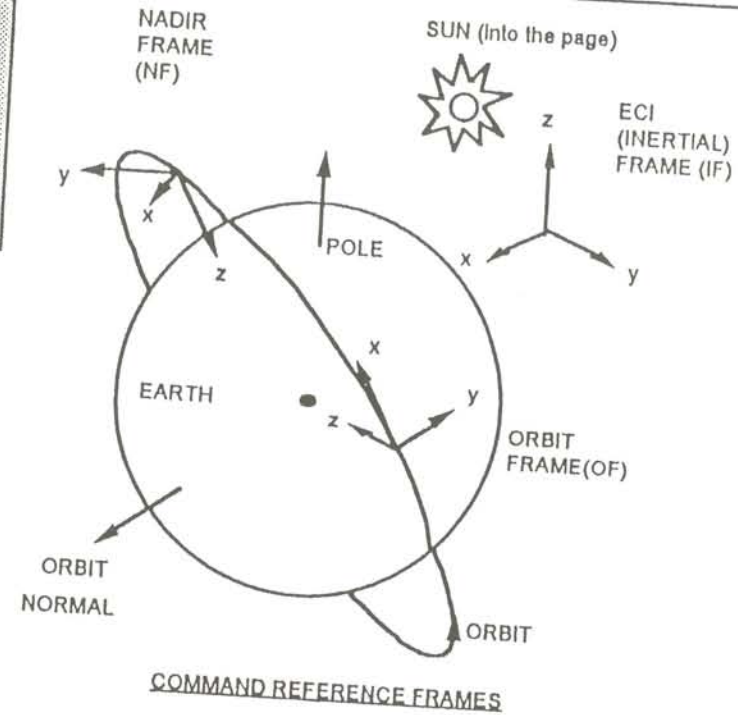
Control Reference Frames Decouple Control By Aligning Control Axes with Critical Sensors and Actuators

- Each ADCS mode has a table-selectable control frame
 - Fixed in nominal body frame of satellite
- Control frames allow decoupling of control axes functions
- Control frame is defined by a quaternion - Q_{b2c}
- **Point**
 - Z control frame axis (Z_c) aligned with altimeter boresight
 - X_c and Y_c attitude determines altimeter pointing
 - Y control frame axis (Y_c) aligned with cross-product of solar panel normal and altimeter boresight
- ΔV
 - X control frame axis (X_c) aligned with current line of thrust
 - Y_c and Z_c attitude determines line of thrust
 - Z control frame axis (Z_c) is (nominally) placed close to the Z body axis (Z_b)
 - Optimum horizon scanner pointing



Command Reference Frames Support GFO Objectives

- **Nadir Frame - Z-axis aligned with geodetic nadir, Y-axis aligned with sun cross geodetic nadir (used in Point state)**
- **Orbit Frame - Z-axis aligned with geocentric nadir, Y-axis aligned with geocentric nadir cross velocity (used in Acquire ΔV and ΔV states)**
- **Inertial Frame - standard ECI frame (test mode)**





Reference Vectors are Measured in the Body Frame

- Used as the basis for rate and attitude determination
- Nadir vector
 - Supplied by one or two horizon scanners
 - Both geocentric and geodetic vectors are provided
- Sun vector
 - Supplied by a subset of 17 sun sensors
 - Three or more valid measurements result in least squares sun vector solution
 - One or two valid measurements provide a coarse sun vector which is used in Acquire Sun
- Magnetic field vector
 - Supplied by three of six magnetometers (three 2-axis sensors)
 - Three orthogonal measurements provide complete magnetic field vector
 - Software compensates for onboard magnetic fields
 - Especially those induced by electro-magnets



Inertial Frame Reference Vectors are Required to Accurately Determine Satellite Attitude and Rate

- **Geocentric nadir vector is determined directly from the orbit propagator**
- **Geodetic nadir vector is computed from geocentric nadir based on satellite latitude**
- **Magnetic field vector is determined by a spherical harmonic model of the earth's magnetic field and the satellite's earth relative position**
 - **The ECR vector is rotated into the ECI frame**
- **Sun vector is determined by a simple model of the earth's orbit about the sun**