Section 1:

Technical Introduction and Orientation

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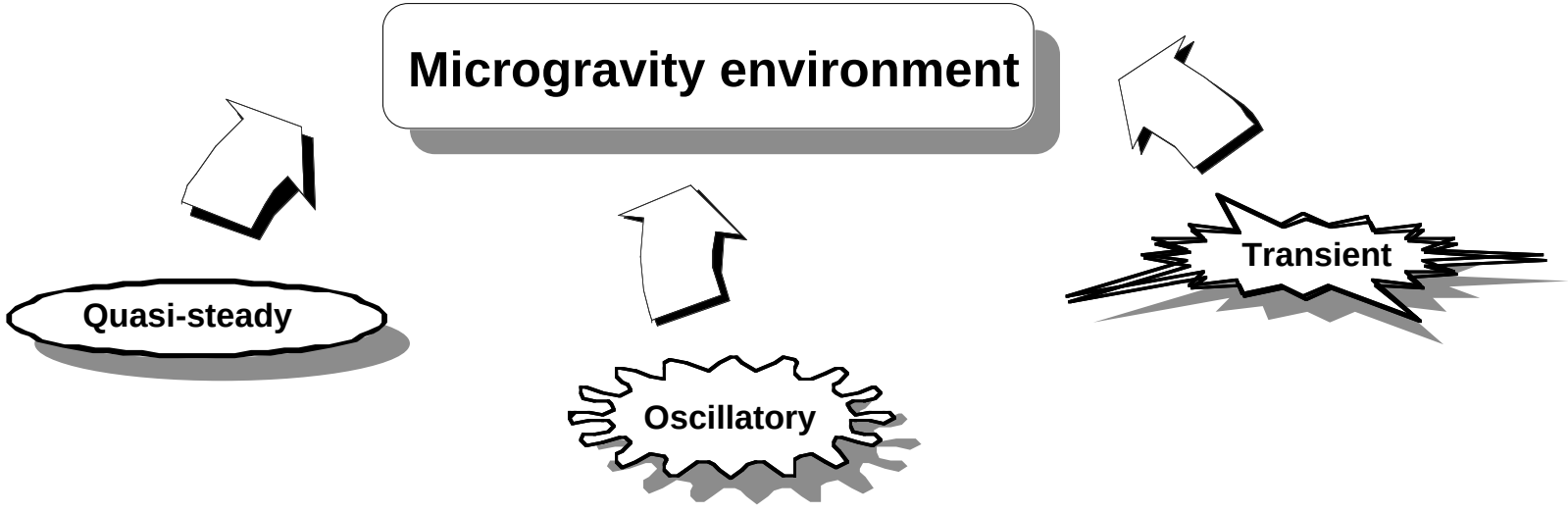
Introduction

- **Microgravity Environment Interpretation Tutorial (MEIT)**
  - ***Purpose:***
    - Convey significant features of the microgravity acceleration environment to the microgravity Principal Investigator teams and other interested parties.
  - ***Content*:**
    - Acceleration Measurement Systems
    - Advanced Acceleration Systems (SAMS-FF)
    - Basics of Signal Processing
    - Analysis Techniques for Quasi-Steady Data
    - Analysis Techniques for Vibratory Data
    - Microgravity Environment of Non-orbital Platforms
    - Highlights of the Microgravity Environment of the Orbiters and Mir
    - Implications for Microgravity Experimenters
    - ISS Acceleration Environment Predictions
    - PIMS Space Station Operation
    - ISS Acceleration Data Flow Demo
    - Vibration Isolation Techniques
    - Predicting Residual Acceleration Effects on Space Experiments
    - Impact of the Microgravity Environment on Experiments

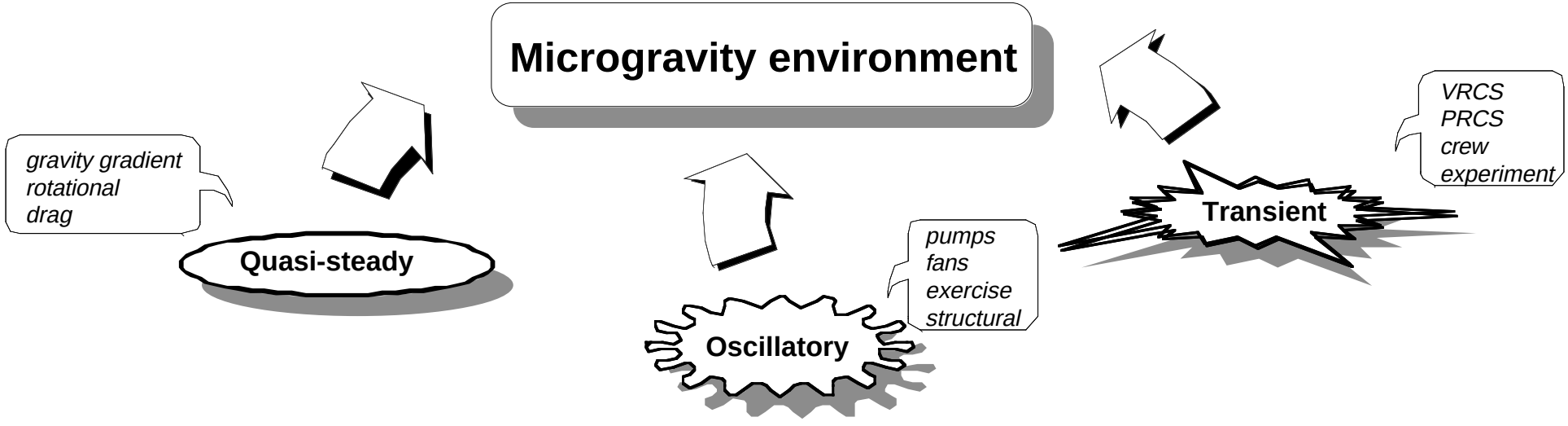
What is a *"microgravity environment"* ?

Major properties



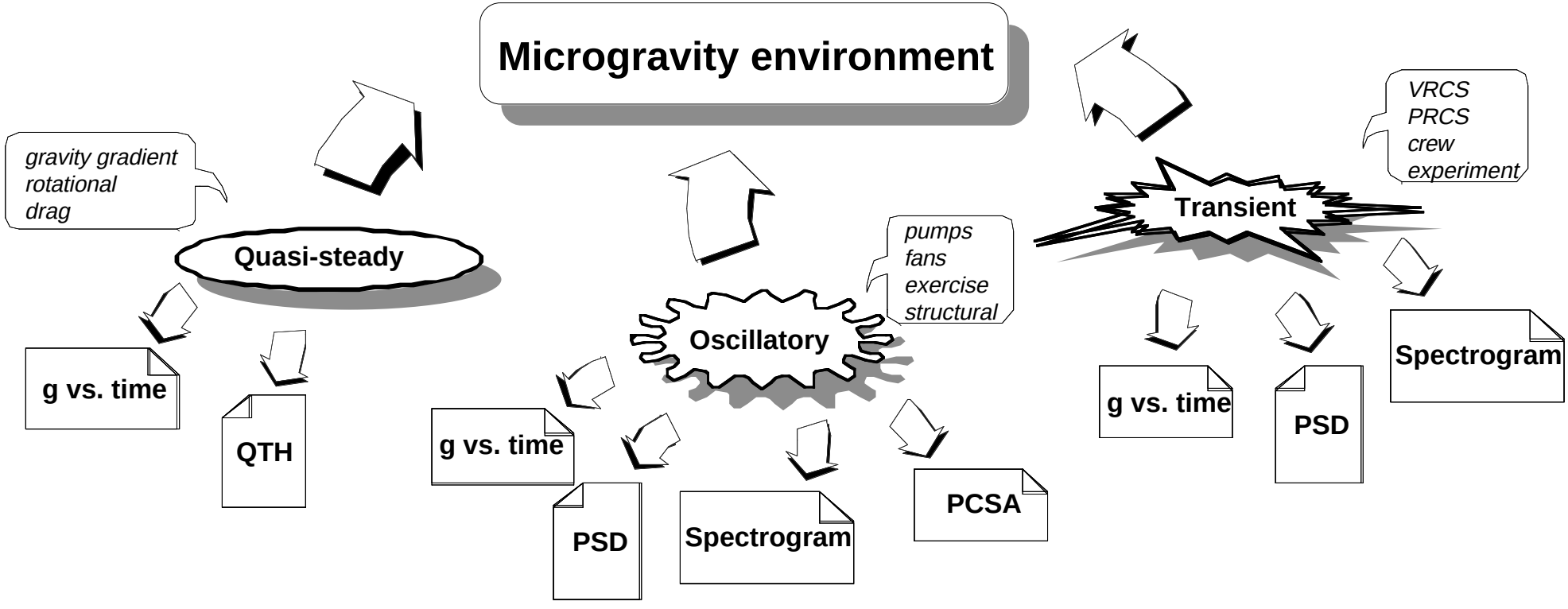
What is a *"microgravity environment"* ?

- **Major properties**
- **What causes these accelerations?**

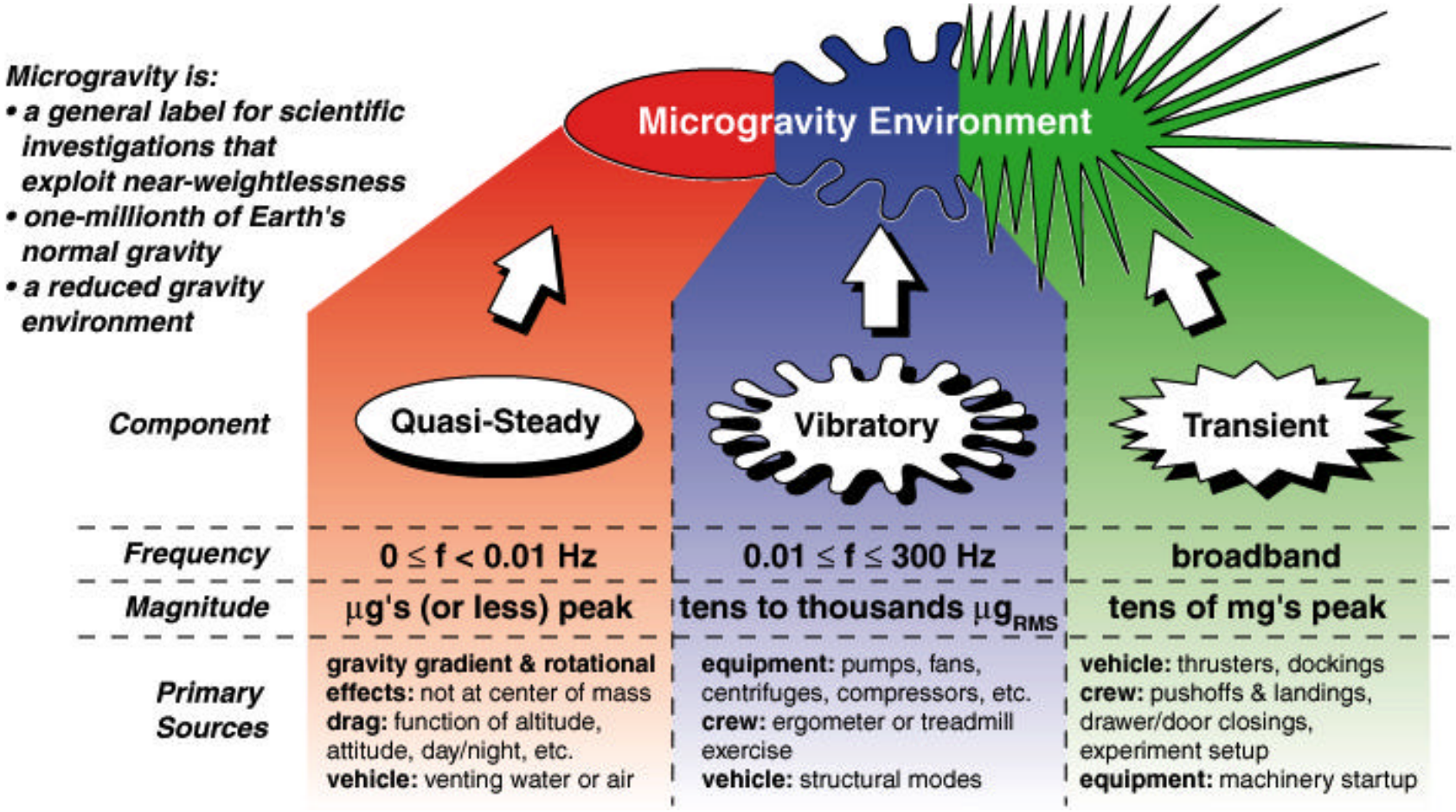


What is a *"microgravity environment"* ?

- **Major properties**
- **What causes these accelerations?**
- **How can we display it?**



Components of the Microgravity Environment



What does all this mean to me?

- **The environment is NOT “zero-g”!**
- **Experiments may be affected by the microgravity environment**
- **This tutorial will explain what the environment is, how we measure it, how we explain it to you, and show what impacts the environment has had on some experiments.**

Acceleration Measurement Systems (common)

- **SAMS:** Space Acceleration Measurement System - instrument which measures accelerations from 0.01 Hz to 100 Hz on Shuttle, Mir, and KC-135. (NASA Glenn)
- **SAMS-FF:** SAMS for Free Flyers - instrument for free flyers (e.g. sounding rockets), Shuttle, and KC-135 which measures linear and roll-rate accelerations. (NASA Glenn)
- **SAMS-II:** Second generation SAMS - instrument which will measure accelerations from 0.01 Hz to 400 Hz on ISS (NASA Glenn)
- **OARE:** Orbital Acceleration Research Experiment - instrument which measures low frequency accelerations from DC up to 1 Hz (NASA Glenn)
- **MAMS:** Microgravity Acceleration Measurement System - instrument which measures acceleration levels to verify the ISS microgravity environment provided to users (NASA Glenn for JSC)

Important terms

- **Consult the tutorial glossary for in-depth explanation of these and other terms**
- **g:** an acceleration unit equal to Earth's gravitational acceleration at sea level (nominally 9.8 $^{m}/_{sec^2}$)
- **mg (milli-g):** an acceleration unit equal to one-thousandth of 1g
- **µg (micro-g):** an acceleration unit equal to one-millionth of 1g
- **reference frame:** reference point for observations of effects of the accelerations experienced on microgravity science carriers, typically either an inertial reference or a vehicle reference

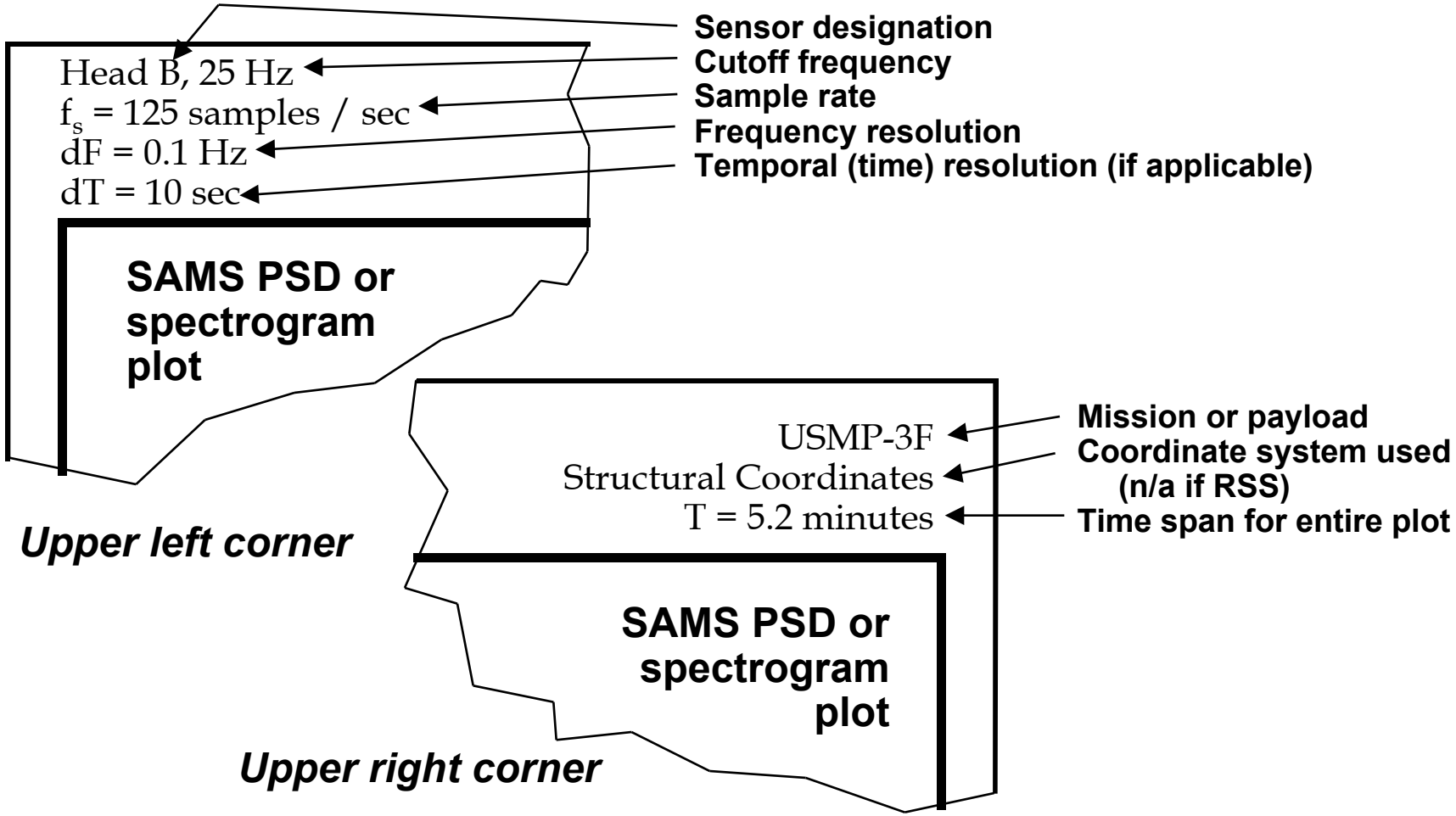
Important terms *(cont'd)*

- **microgravity environment:** an environment in which the effects of gravity are small compared to those we experience on Earth
- **oscillatory:** term used to describe vibratory disturbances with frequency content greater than 0.01 Hz
- **transient:** signals that are impulsive in nature; passing quickly into and out of existence
- **quasi-steady:** a signal which varies at a very low frequency, typically below 0.01 Hz

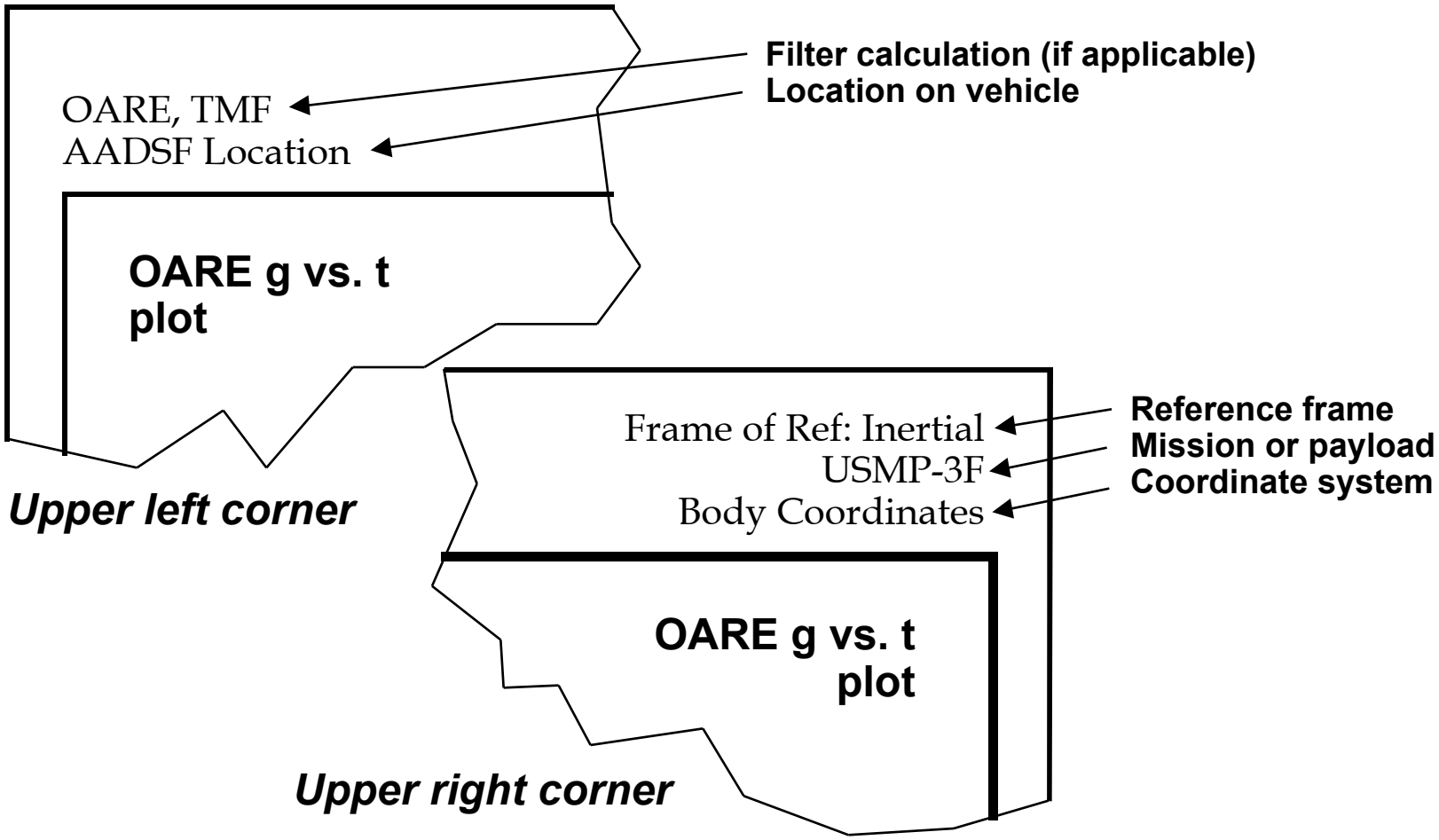
Important terms *(cont'd)*

- **Nyquist criteria:** sampling rate must be at least twice that of the highest frequency contained in the signal of interest
- **cutoff frequency (f_c):** corner frequency in filter response; highest unfiltered frequency of interest
- **sample rate (f_s):** rate at which an analog signal is sampled ($^{samples}/_{sec}$)
- **power spectral density:** a function that quantifies the distribution of power in a signal with respect to frequency
- **spectrogram:** a 3-D representation of the power spectral density as a function of time

SAMS Plot Information

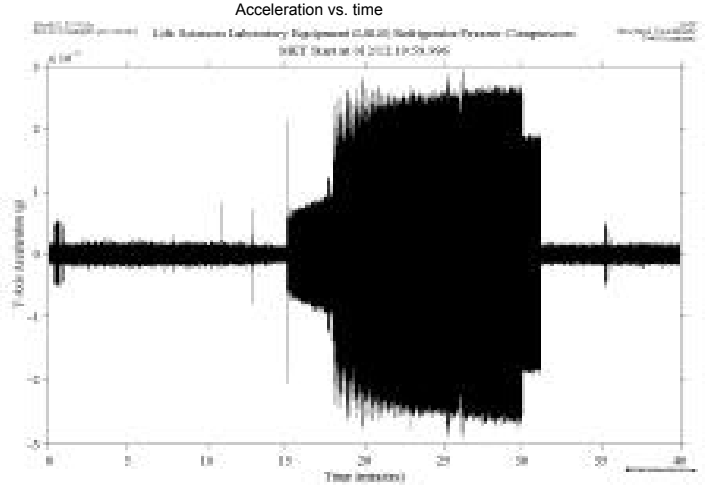


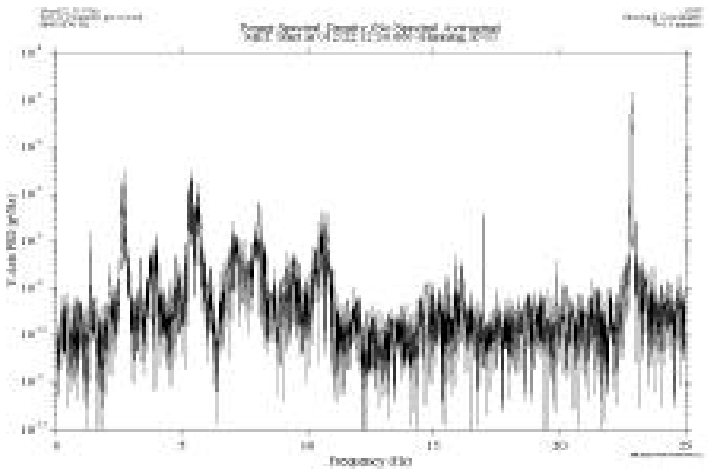
OARE Plot Information

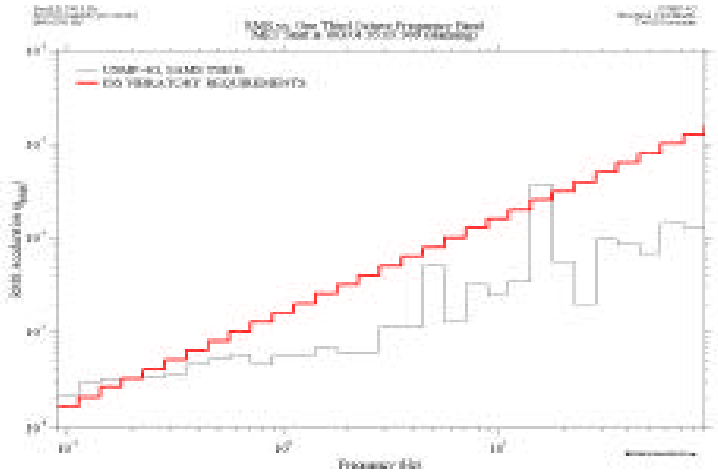


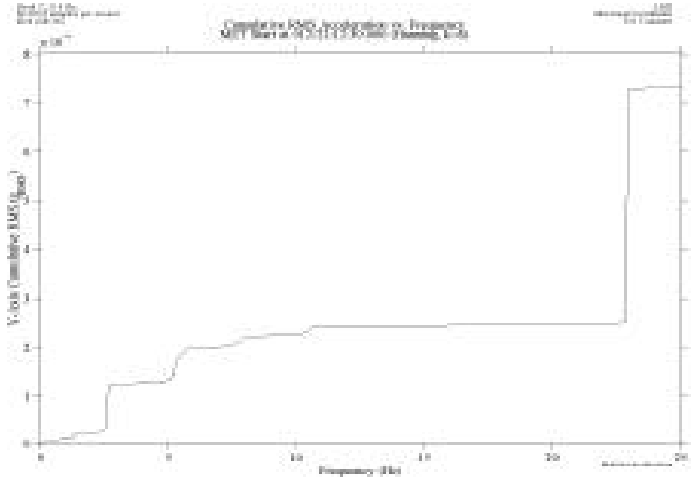
Plot Examples

Acceleration vs. time

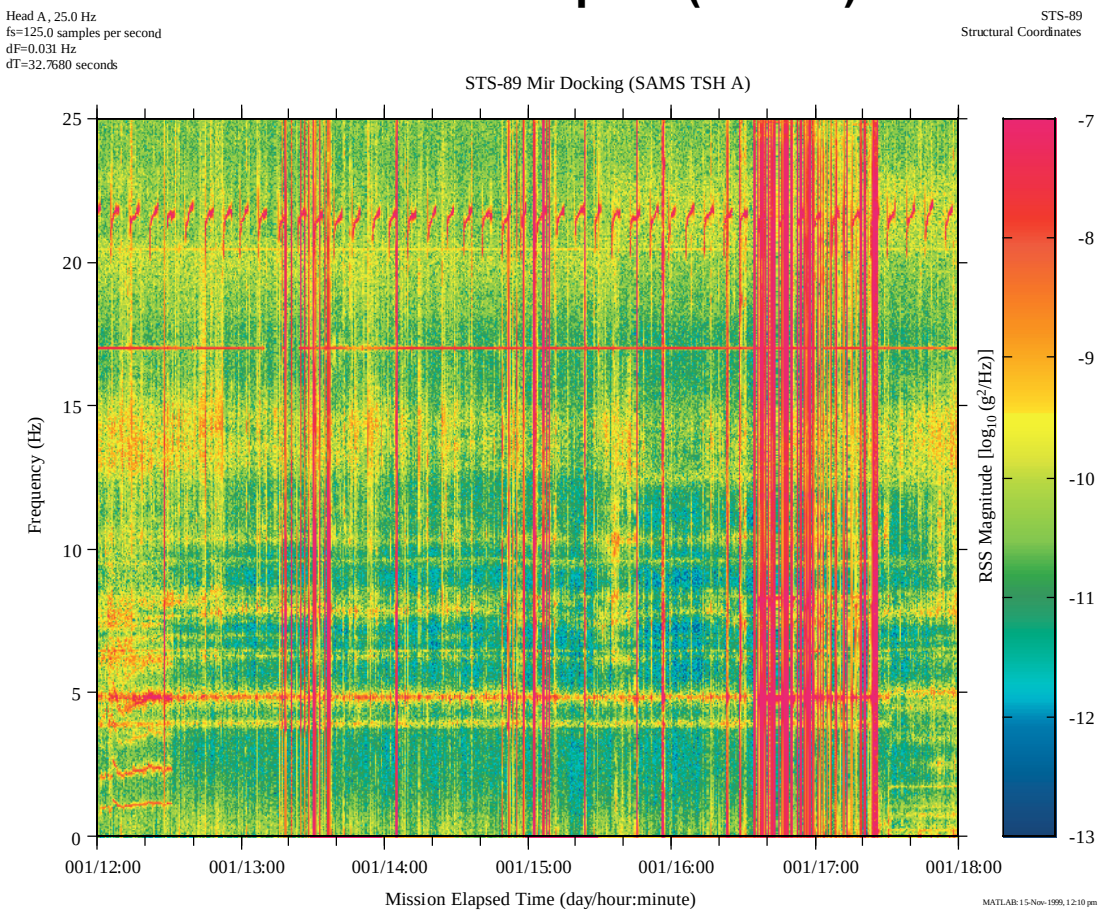








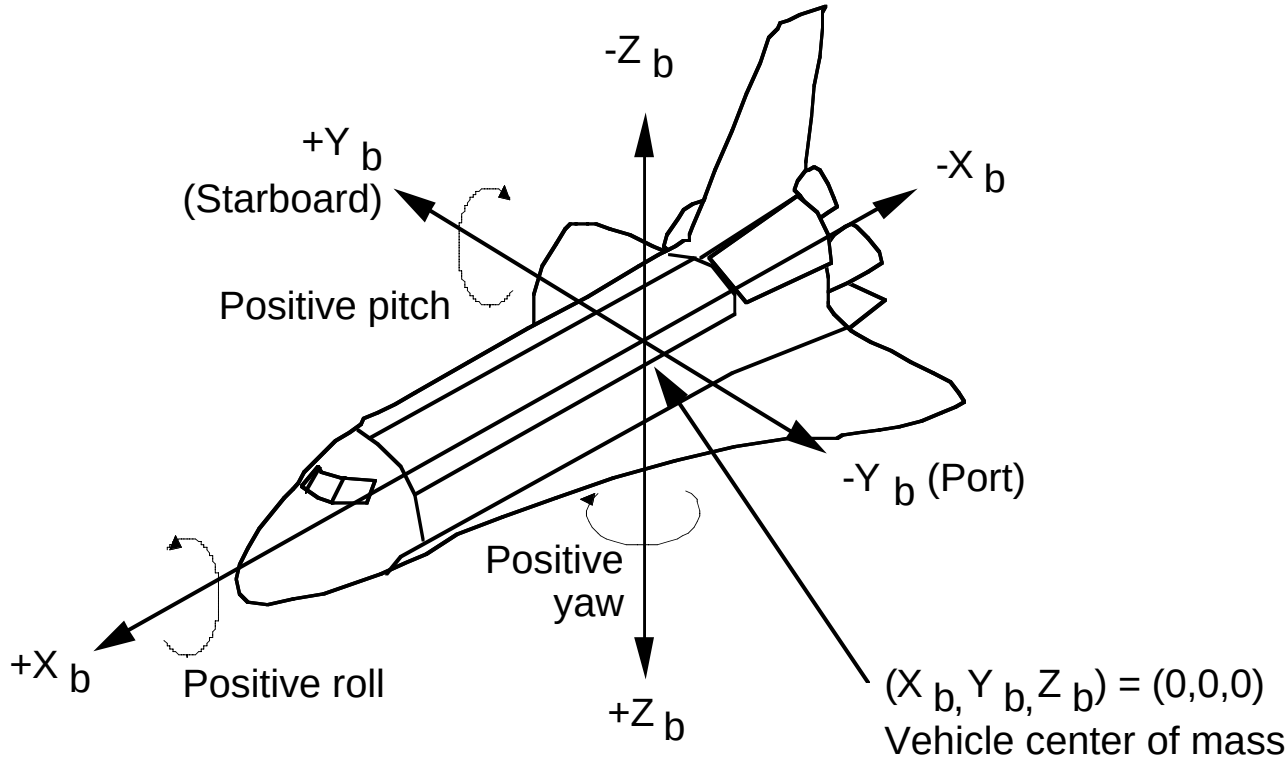
Plot Examples (cont'd)



Spectrogram (acceleration vs. frequency vs. time)
Shuttle/Mir docking

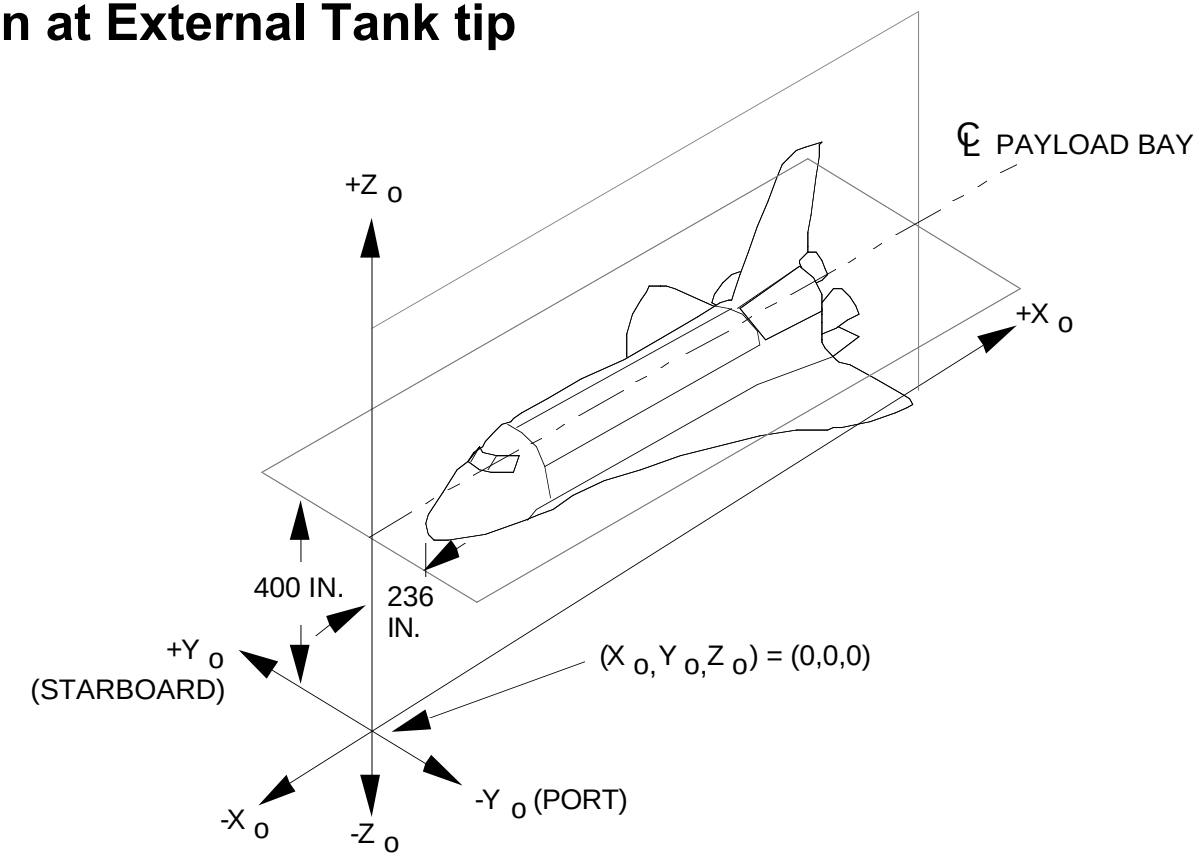
Orbiter Coordinate Systems

- **Body coordinate system**
  - **origin at vehicle center of mass**



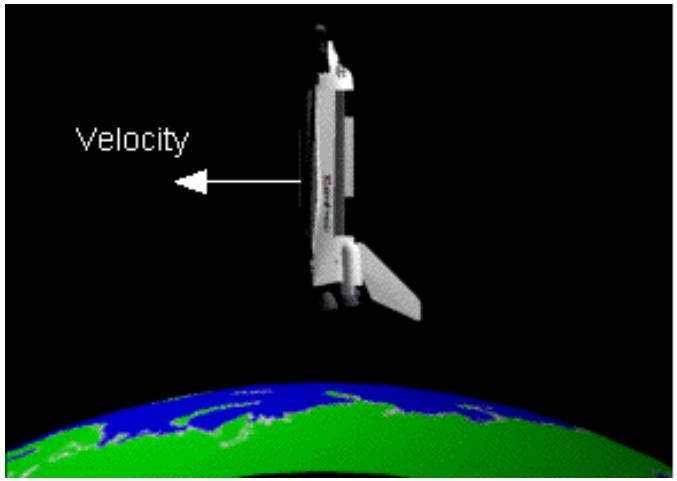
Orbiter Coordinate Systems (cont'd)

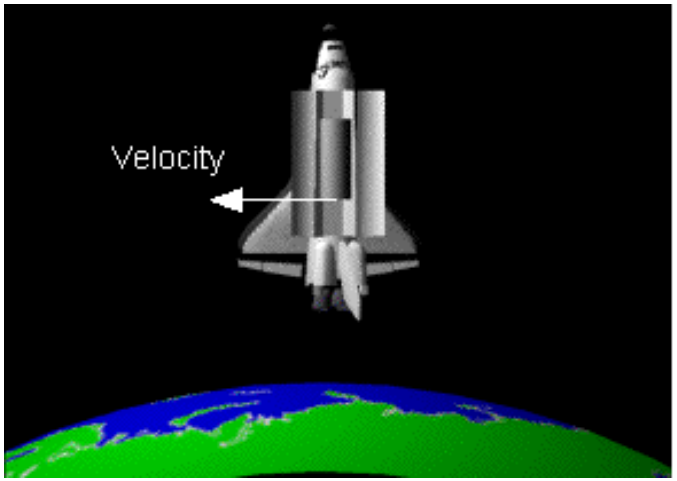
- **Structural coordinate system**
  - **origin at External Tank tip**



Orbiter Attitudes

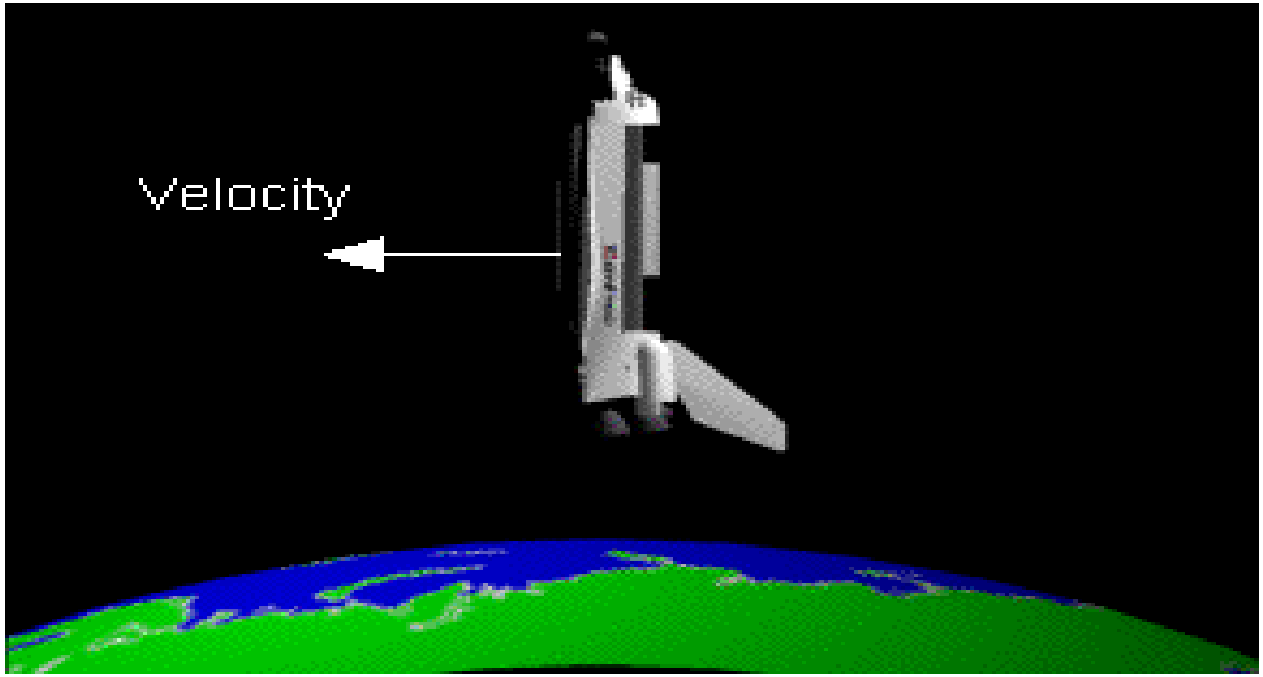
- **Orbiter has two main attitudes**
  - **Local vertical / local horizontal (Earth oriented)**
  - **Inertial (quite often sun oriented)**
- **Designation of attitudes**
  - **pitch / yaw / roll angle relative to airplane mode**
    - e.g. PYR: 90°, 0°, 90°
  - **body axes oriented to nadir (toward Earth) and flight direction**
    - e.g. -XLV / +YVV





Frame of Reference

- **Fixed frame of reference determines sense of observed acceleration**
  - **Inertial reference frame: frame fixed with respect to inertial space**
  - **Science reference frame: frame fixed with respect to vehicle**



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