FAME Error Budget Requirements Flowdown

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Top Level Science Requirements (2.5 yr Mission)

- Astrometric requirements for 5 <= m_v <= 9 stars
  - position in two orthogonal directions accurate to 50 μas (1σ)
  - proper motion in two orthogonal directions accurate to 50 μas/yr (1σ)
  - parallax accurate to 50 μas (1σ)
- Astrometric accuracies for 9 < m_v <=15 stars proportional to 1/sqrt(apparent brightness)
- Photometric accuracy for 9 <= m_v <= 15 stars in full astrometric passband and in four color bands
  - individual observations
    - millimagnitudes at m_V = 9.
    - 0.04 mag at m_V = 15.
  - mission
    - tenths of a millimag at m_V = 9.
    - 0.005 mag at m_V = 15.

Approach To Filling In the Error Budget

- Break out the measurement and analysis process into its parts
- Use this framework to identify error sources and model allowable errors for each of the parts
- After individual errors are identified and quantified, collect and reorganize them if / as required

Top Level Error Budget Structure (1)

- The baseline accuracy of each individual star measurement along scan in a spiral is 600 μas (1σ) after processing
  - contributions to the 600 μas error include
    - “centroiding” – location of star image on CCD relative to CCD coordinates and instrument clock time
      - independent of where the CCD is looking
    - determination of look direction of CCD along spiral as a function of instrument clock time
      - uses measurement of many grid stars and basic angle separation to reconstruct the motion of the look directions and time evolution of the basic angle.
      - uses physical understanding or smoothness to reconstruct motion
      - many systematic errors (example: CCD nonuniformity) are accounted for at this stage
      - may use information from the global reconstruction

Top Level Error Budget Structure (2)

- The multiple observations per star over the mission life reduce the effects of random errors in order to meet science requirements
  - primary drivers for the “improvement factors” are the Sun angle, rotation period, and precession period
  - the nominal values of the mission parameters are designed to yield acceptable “improvement factors”

- Multiple observations per star are less effective at reducing the effects of unaccounted-for systematic errors
  - these must be kept small

Location of Star Image on CCD

- determines the location of star image on CCD relative to CCD coordinates and instrument clock time
- Sources of error include
  - capturing enough of the star image to centroid
    - sets in-scan and cross-scan window size
    - window size is related to the position prediction accuracy
    - window size also bounded by confusion and faint companions
  - CCD MTF
  - optical distortion
  - mismatch between rotation rate and instrument clock rate
  - instrument clock errors over 1.56 sec time period
  - image blur from jitter over 1.56 sec time period

Reconstruction of Rotation Over a Spiral

- Precision to support estimation of the parameters of error models
- Stability over times shorter than can be addressed by the series expansion model of the rotation
  - what is this minimum time?
    - depends on the noise processes.
    - educated guesses required in order to set requirements.
    - critical to the data reduction is the number of parameters that must be estimated per rotation.
  - instrument
    - e.g., basic angle, optical distortion
  - spacecraft
    - attitude
- Ephemeris