DRAFT

Outline for FAME Requirements Document 10/25/00

I. General Description of Mission:

The FAME space observatory will determine the positions, proper motions, parallax and photometric intensity of about 40 million stars. It will be the first astrometric mission to measure star positions in the microarcsecond (μas) range. At visual magnitudes 5-9, it will achieve measurement accuracies of 50 μas, 50 μas/yr, 50μas and 0.001 magnitudes.

II. Parameters of the Instrument and Spacecraft

The FAME mission will achieve this by flying a telescope with two fields of view separated by 81 degrees that has a focal plane array of CCDs. The baseline design of this focal plane contains twenty-four 4096 by 2048 pixel CCDs. Four of the CCDs are used for four colors. Six other CCDs are covered with neutral density filters to measure stars brighter than 9^{th} visual magnitude. This focal plane will scan the sky in a spiral pattern that will rotate with a forty-minute period and precess with a 20-day period. The angle between the sun and axis of rotation of the spacecraft will be 45 degrees.

The parameters of the telescope are:
Focal Length 15 m
Size of Aperture 0.6 m along scan, 0.16 cross scan
Field of View two approximately 1 degree separated by 81 degrees along scan direction

The parameters of the CCDs are:
Number of pixels: 4096 by 2048
Pixel Size 15 microns
Wavelength Range 0.4-.0.9 μm
Quantum Efficiency 0.8
Operate in TDI mode

Spacecraft Parameters:
Rotation Rate 40 minutes
Precession Rate 20 days
Sun/Rotation Axis angle 45 degrees

Catalog: star positions accurate to 0.1” at time of observation

This results in the following:

Integration time 1.56 seconds
Plate Scale: 13.75 mas/μm
206.265 arcseconds/pixel or 1μradian/pixel

Rotation Rate: 540”/sec

Arcseconds subtended by CCD along scan direction: 843.8”

PSF(FWHM)
Along scan ~ 1 pixel
Cross Scan ~4 pixels

N(photons) ~900,000 for visual magnitude 9.

III. Measurement Accuracy

The measurement accuracy of the FAME Observatory will be divided into three parts, single measurement accuracy from the CCD measurements, the accuracy achieved along the spiral scans and finally the accuracy needed for the global solution. The mission is predicated on the fact that the instrumental effects can be solved for from a large database of repeated measurements of the 40 million stars. It is expected that over the two and one half years that there will be over a thousand measurement of each star. Systematic effects will need to be solved for to an accuracy of 10μas.

a. Single Measurement Accuracy

Given the instrumental parameters, the accuracy of a single measurement will depend on the fitting of the Point Spread Function (PSF) to an average of 20 cross scan pixels sampled over 10 along scan pixels centered on the star. For the FAME mission, this must be $1/350^{th}$ of a pixel along scan for a star of 9^{th} visual magnitude. This is equivalent to 580 μas accuracy for a single measurement. The cross scan accuracy which will be obtained from a complete sampling of a 10 (along scan) by 20 (across scan) array

b.. Scan Accuracy/Jitter

The sc.an rate of the instrument must be constant to within the following table:

Stability

	Along scan				Cross scan			
Rotation stability(Hz)	5	1	0.1	0.01	5	1	0.1	0.01
Pixel Jitter	0.1	0.01	0.03	0.1	1	0.1	0.3	1

c. Stability of Basic Angle: The stability of the basic angle is given as 10 μas or 0.015 nanometers. The time scale that this must be maintained is on timescales of 10 minutes.

IV. Timing/Frequency Accuracy

a. Instrument: The CCD must clock out at 200Mhz. This will correspond to 10^{-9}

b. S/C: To achieve an accuracy of 10 μas in one rotation, the clock needs to have a stability of $1*10^{-11}$ per rotatio

c. c. Ground System: the timing of the ground system is determined by the accuracy of the spacecraft ranging.??

V. Knowledge of vector S/C velocity is needed at the level of 1 cm/s to correct for aberration at the 10 μas level. Knowledge of S/C position is needed at the 100 m level to correct for????

VI. Instrument/S/C Alignment Requirements

Alignment of CCDs on Focal Plane Total 50”
Alignment of focal Plane with Optical Axis
Alignment of Optical Axis to rotation axis of S/C

Precession/other effects: not to exceed more than 6 pixels across individual CCD

Questions from September Meeting:

1. Resolve pixel precession motion and tilt
2. Resolve Error Budget Jitter
3. Instrument alignment to rotation axis/CCD alignment on focal plane
4. Stability of Basic Angle
5. Thermal Requirements
6. Clock requirements S/C
7. Instrument Frequency Requirements
8. Error Budget in detail