FAME Data Simulator Development Plan
Version 0.2, December 14, 2000

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ABSTRACT

A plan is presented for the development of prototype software to provide simulated output from the FAME satellite for use by the FAME software development team. The prototype software will be increasingly modified and enhanced to provide for more complexity and realism. A rough outline of the path to this end-goal product is indicated.

1. Objectives

1.1. What the Data Simulator Is

The ultimate goal of the data simulator is to deliver artificially generated observations in the form, accuracy, distribution, and quantity (over limited times) expected from the FAME spacecraft/instrument once operational.

The **initial** data simulator development goal is to construct a *prototype* software product to generate realistic, though very basic, data, properly formatted, for the FAME pipeline software to use as input. The intent is that such data will verify that the data format interfaces (data simulator outputs and pipeline inputs) are in agreement and to provide inputs to test the other pipelines. This initial version will not actually generate rasters and postage stamps but will instead deliver centroids for the downstream astrometric pipeline.

After the prototype data simulator is running successfully, enhancements will be added incrementally which will lead to the generation of data expected to be more representative of what will actually be encountered in the mission. For example, the data simulator will evolve to include increasingly more complex departures from idealized spacecraft and instrument. Such effects include perturbations to an idealized perfectly spinning rigid body spacecraft, CCD cosmetic defects and charge transfer inefficiencies, optical distortions, and the convolution of stellar spectral energy distributions of stars with PSFs. Additionally, subsequent versions will generate rasters and postage stamps.

At this early (December 2000) stage, the order in which the enhancements are added is not yet specified. It will depend upon requirements developed elsewhere from sources largely external to the data simulator development team.

1.2. What the Data Simulator Is Not

It should be made clear at the outset that, while the data simulator will grow in complexity and, hopefully, realism, the sole purpose of this simulator is to provide data to test the pipeline software and to understand the impact of various effects on data reduction and analysis. The data simulator is **NOT** the mission simulator and is not expected to be developed further, by the current data simulator development team, to satisfy other needs that may exist within the project. It is specifically not an objective of the data simulator to be a comprehensive suite of software for engineering testing and analysis.

1.3. Prototype Assumptions

This first, simple, "prototype," data simulator, will assume the following:

- the spacecraft spin dynamics are modeled using *SymTop, a software package written by Marc Murison; the prototype simulations will include the effects of spacecraft precession and nutation, but will ignore higher level perturbations such as fuel sloshing, gravitational gradients, etc.;*
- *the instrument CCDs are perfect: no charge-transfer-inefficiencies, no bad columns, hot pixels, non-linearities, flat field irregularities, read noise, etc.;*
- *catalog star positions are affixed to a rigid, inertial J2000 celestial sphere and precession, nutation, parallax, proper motion, aberration are all initially ignored in the prototype;*
- *optical variations across the focal plane, as modeled by LMMS, can be accounted for, but changes to the optical system (due, for example, to flexure) will not be accommodated in the prototype;*
- *minor mis-alignment and/or rotation of CCDs from the as-designed nominal values will be supported by the prototype;*
- *the spectral energy distribution of stars will be taken into account for the generation of centroids only if the input catalog, or a supplement thereto, is given to the data simulator team which provides narrow-band fluxes or spectrophotometry for (some of) the catalog stars;*
- *thermal variations in the instrument (which might lead to physically moving CCDs in the focal plane or affecting the electronic signals) will be ignored in the prototype;*

2. Implementation

2.1. The Team

A Data Simulator Development Team has been assembled consisting of five staff astronomers at the Flagstaff Station of the U.S. Naval Observatory: Hugh Harris, Stephen Levine, Dave Monet, Jeff Munn, and Jeff Pier (team leader). This team will develop code which utilizes various inputs from other resources within the FAME project to meet the objectives.

2.2. standards

Code developed by the data simulator development team will conform to the current, and presumably evolving, FAME software standards. The current standards are explicated in the *FAME Software Management Plan*, Version 2, dated June 13, 2000. This document can be found via the FAME web site `http://fame.usno.navy.mil` under `Document Archive/Browse --> Working Group Documents --> Software Management --> FAME Software Management Plan`.

Input and output file formats will comply with the FAME data model. The current data model is available via the web site `http://fame.usno.navy.mil` under `Document Archive/Browse --> Working Group Documents --> Pipeline: Algorithms & Development --> Data Model`.

2.3. The Inputs

A number of inputs are required for the data simulator:

- an input star catalog – the initial catalog will that of FAME grid stars provided by Sean Urban, and will slowly evolve into the actual FAME project input catalog.
- a model of the spacecraft dynamics, *SymTop, developed by Marc Murison. The current SymTop version runs in a Microsoft Windows environment. Dr. Murison will deliver a version of SymTop to the data simulator development team stripped of its Windows-based GUI which can be compiled with gcc compiler. Responsibility for the continued development and support of SymTop will remain with Marc Murison and is not the responsibility of the data simulator development team.*
- *a set of monochromatic model point-spread functions (PSFs) developed by Scott Horner for numerous positions in the focal plane, and for a range of colors.*
- *a model of the instrument's focal plane to be agreed upon project-wide.*

A top-level flow diagram follows. The data simulator development team is responsible for code inside of "Data Simulator" and for assuring that it can read properly formatted inputs and generate

properly formatted outputs.

2.4. The Data Simulator Modules

A flow diagram for the prototype "Data Simulator" module follows. Briefly, the modules within the prototype "Data Simulator" are:

- executive - the "main" program, loads initial parameters, initial star catalog tiles, space craft parameters, and keeps track of simulator run beginning and ending, maintains and increments the simulator's two clocks (the "true" clock and the instrument clock). Other modules are called from, and return to, the executive.
- fov - calculates the angular extent of the sky viewed through the two fields of view at the current clock tick.
- tiles - checks that the current star input catalog tiles in memory cover the fields of view, fetches additional tiles if needed.
- skyXform - transform observed sky onto the focal plane;
- locate - place the catalog stars onto CCDs; accumulate positions with time and CCD id number;
- fiducials - determine times catalog stars cross CCD fiducials, generate output.

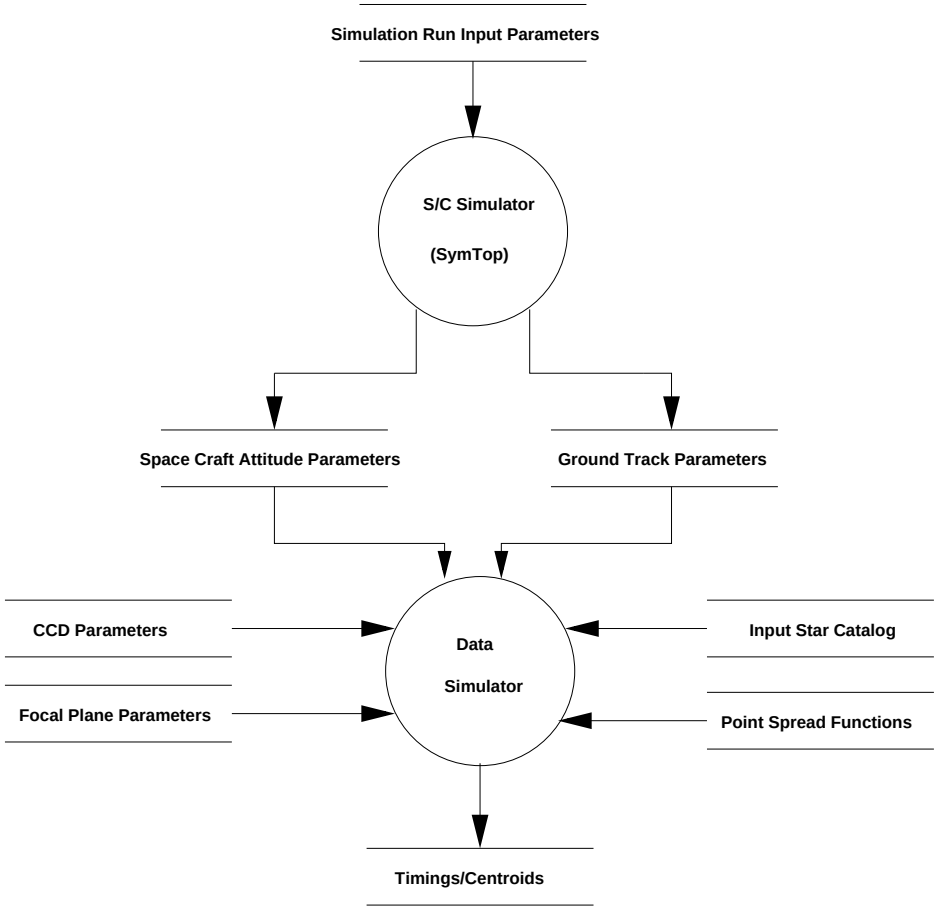

Fig. 1.— Top-level Flow Diagram

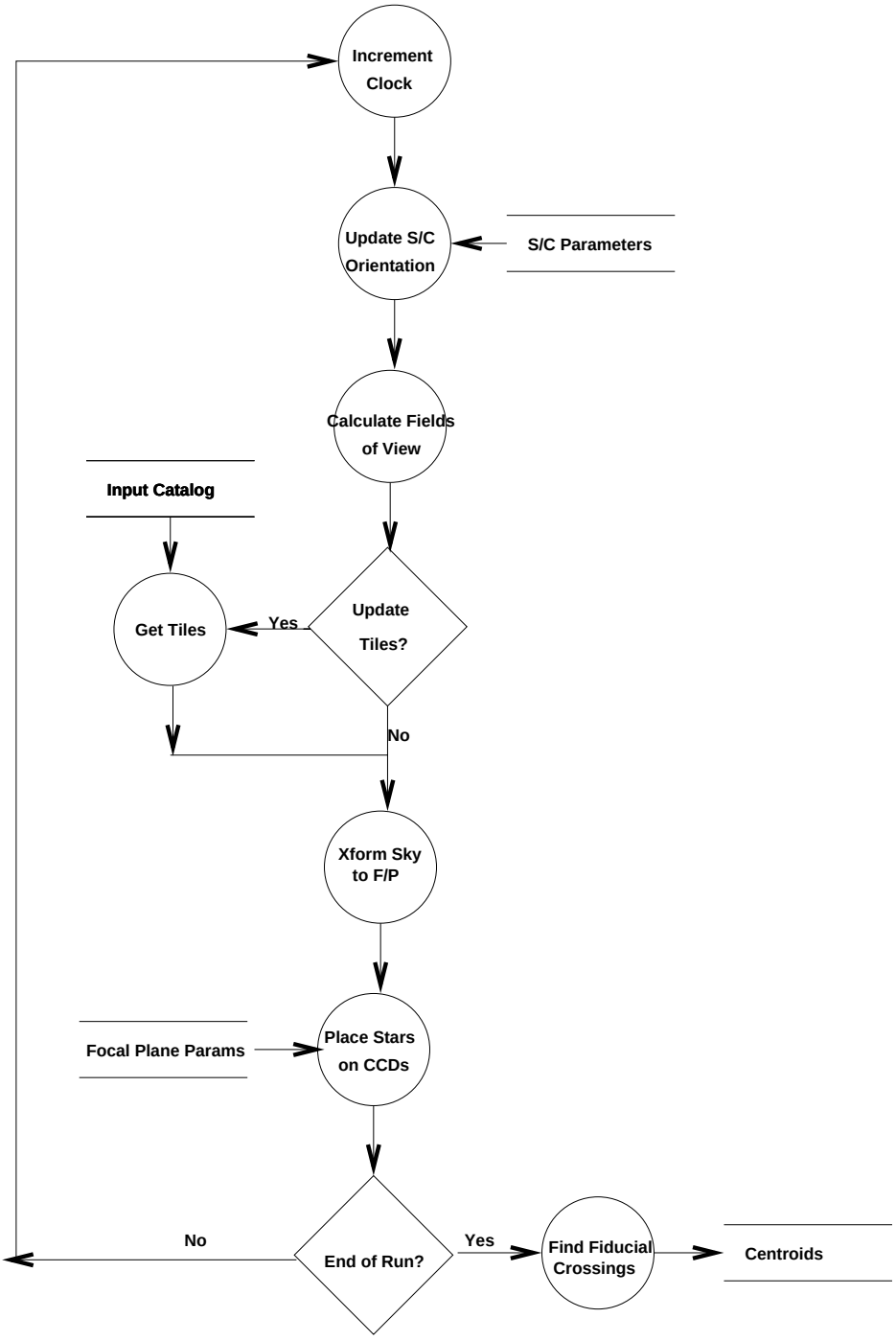

Fig. 2.— The Top-Level Data Flow diagram for the Simulator

2.5. The Outputs

All outputs will conform to the data model.

Eventually, the data simulator output will consist of 2-d rasters of pixels ("postage stamps") for unbinned stars and 1-d vectors of pixels binned in the cross-scan direction for binned star observations. Initially, however, the prototype data simulator will by-pass the generation of pixel information and provide, instead, a downstream output of centroids.

3. Schedule

- Establish Data Simulator Development Team — 15 Nov 2000
- Establish Data Simulator Development Plan (Draft) — 15 Dec 2000
- Deliver Prototype Data Simulator — 01 Mar 2001
- Begin Data Simulator Enhancements — 01 Mar 2001
- Phase B Data Simulator Studies Report — 01 Jun 2001
- Finalize Data Simulator Development Plan — 01 Jul 2001