SEQ_POINTER: NEXT GENERAT'1ON, PLANETARY SPACECRAFT REMOTE SENSING SCIENCE OBSERVATION DESIGN TOOL

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ABSTRACT

Since Mariner, NASA-JPL planetary missions have been supported by ground software to plan and design remote sensing science observations. The software used by the science and sequence designers to plan and design observations has evolved with mission and technological advances. The original program, PEGASIS (Mariners46 and 7), was re-engineered as POGASIS (Mariner 9, Viking, and Mariner 10), and again later as POINTER[2] (Voyager and Galileo). Each of these programs were developed under technological, political, and fiscal constraints which limited their adaptability to other missions and spacecraft designs.

Implementation of a multi-mission tool, SEQ_POINTER, under the auspices of the JPL Multi-mission Operations Systems Office (MOSO) is in progress. This version has been designed to address the limitations experienced on previous versions as they were being adapted to a new mission and spacecraft. The tool has been modularly designed with subroutine interface structures to support interchangeable celestial body and spacecraft definition models. The computational and graphics modules have also been designed to interface with data collected from previous spacecraft, or on-going observations, which describe the surface of each target body. These enhancements make SEQ_POINTER a candidate for low-cost mission usage, when a remote sensing science observation design capability is required.

The current and planned capabilities of the tool will be discussed, The presentation will also include a 5-10 minute video presentation demonstrating the capabilities of a proto-Cassini Project version that was adapted to test the tool.

The work described in this abstract was performed by the Jet Propulsion Laboratory, California Institute of Technology, under contract to the National Aeronautics and Space Administration.

Keywords: remote sensing science observation, adaptable tool, interchangeable models, digital terrain map-defined celestial body

INTROD1JCTION

POINTER provides functionality analogous to a professional photographer's process of preparing for and taking photographs. POINTER supports this process for a remote robotic photographer that has no control over the environment where it has been sent to gather images and other data of the surrounding phenomenon. The functions which are similar to the photographer's process define the foundation of POINTER. These foundation functions are listed and illustrated in Figure 1. In SEQ_POINTER, the functions have been designed and implemented for multiple missions. The mission specific capabilities are incorporated via a process called adaptation.

1, Cognizant Development Engineer (CDE)

2, **Planetary** Observation Instrument Targeting and Encounter Reconnaissance

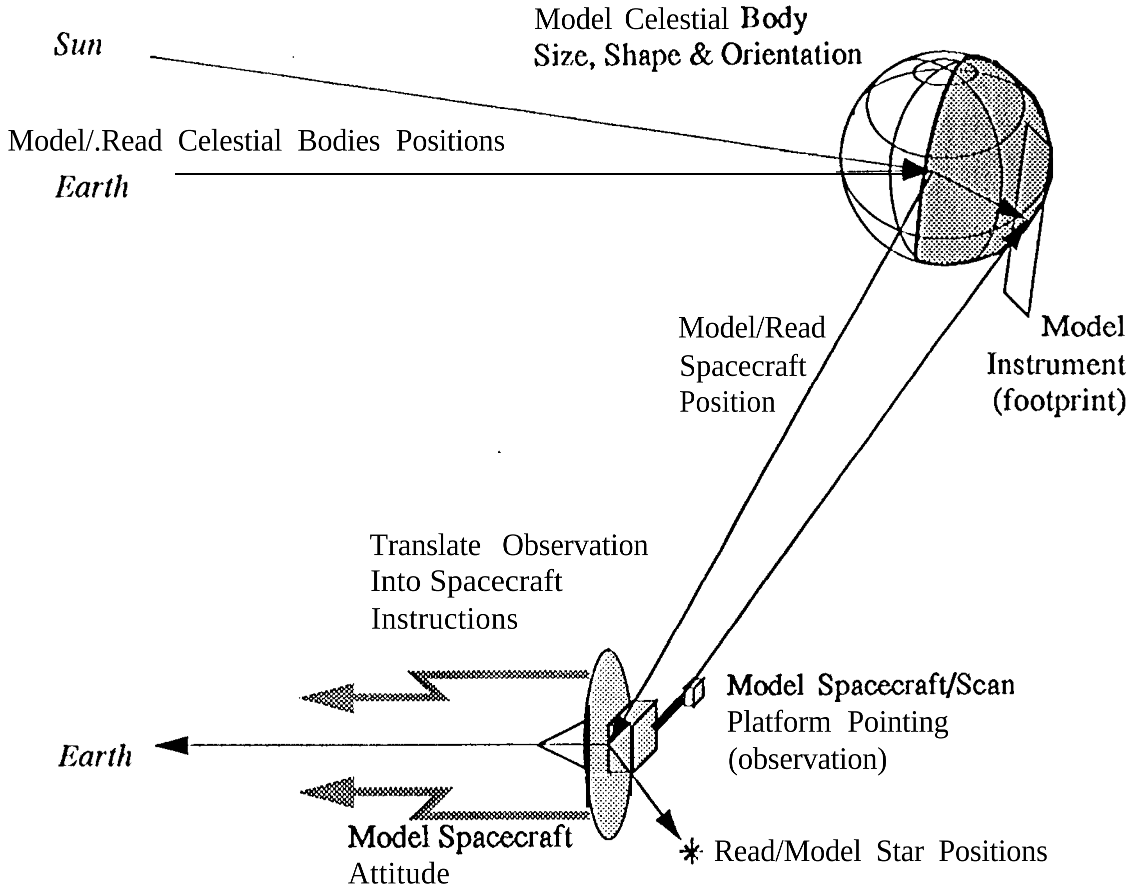

Figure 1. POINTER Foundation Functions

CURRENT CAPABILITIES

The foundation functions are augmented by capabilities which allow SEQ_POINTER to fit within AMMOS[3], the multi-mission operations support system being developed by MOSO. The tool capabilities with respect to AMMOS are illustrated in Figure 2. The primary capability is the interface with the Sequence file. The Sequence file contains spacecraft instructions and ground software directions in the form of requests. Requests perform remote sensing as well as fields and particles science observations and engineering activities during mission operations. The remaining capabilities are the interfaces with the Spacecraft & Celestial Body Ephemerides file and the Spacecraft Clock file. The Spacecraft & Celestial Body Ephemerides file(s) lump together spacecraft, planetary, and satellite ephemerides (currently NAIF[4] and star catalog(s). The Spacecraft Clock file provides spacecraft clock adjustment data referenced by the tool.

The upper portion of Figure 2 illustrates the primary SEQ_POINTER operator displays, the operator interface and observation design depiction. The operator interface (left) is an X Window S ystem/Motif application. It provides the operator with capabilities to manipulate observation design instructions and to perform a simulation of spacecraft execution instructions which are graphicall y depicted (on the right by the Project module). Figure 3 contains images illustrating sample menus (top) and a sequence component (bottom) from the operator interface. The observation

3. Advanced Multi-Mission Operations System
4. Navigation Ancillary Information Facility

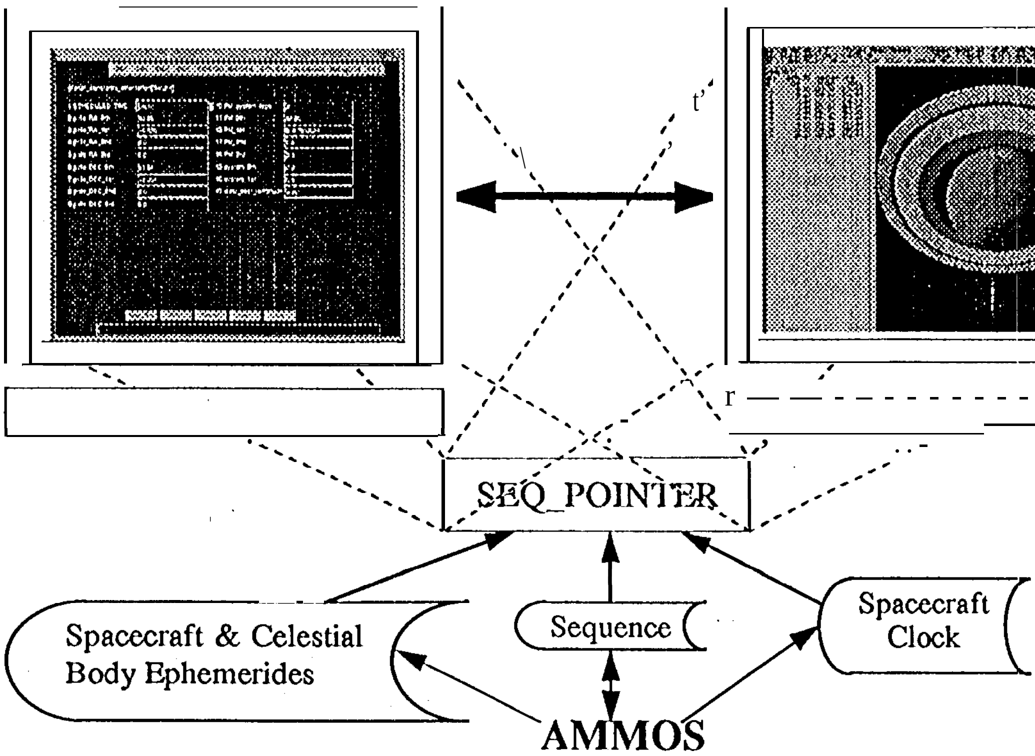

Figure 2. SEQ_POINTER in the MOSO AMMOS

graphically depicted is a perspective projection of Saturn with events (footprints) from a Cassini Project instrument. Figure 4 contains a sample image of the same observation from a different vantage point than depicted in Figure 2. The implemented module in the Project module family is an X-Window System/Motif/PHIGS+[5] application. The depiction of the target body is data driven, based-on a PHIGS data structure that models the surface of the body. The data structure can be derived from a variety of sources: an oblate-spheroid body shape algorithm or the same algorithm with an electronic version of a USGS[6] Albedo Image file. The Saturnian rings are modeled in the same fashion. However, the data structure for the rings is created at run-time from ring system constants read by the tool.

ARCHITECTURE

To facilitate a mission adaptable tool, SEQ_POINTER has been organized around the concepts of modular executable programs (module families) and interchangeable models. The tool comprises three module family groups: infrastructure programs, observation design utility programs, and observation activity programs. The groups and some of the constituent module families are illustrated in Figure 5. The infrastructure group consists of module families which contribute the underlying data flow architecture for the tool: Operator Interface, Activity Design, Modeler, Position, Project, Present, and Targeting Update. A description of each module appears in Table 1.

The design utility and observation activity program groups consist of activity and command modules, the sequence components of an observation, The design utility program group currently consists of two module families, Solar System Body/Surface Point Trajectory and Stellar Position. These modules are used to produce geometric and photometric data the operator analyzes for

5. Programmer's Hierarchical Interactive Graphics System (ANSI-Computer Graphics)
6. United States Geological Survey

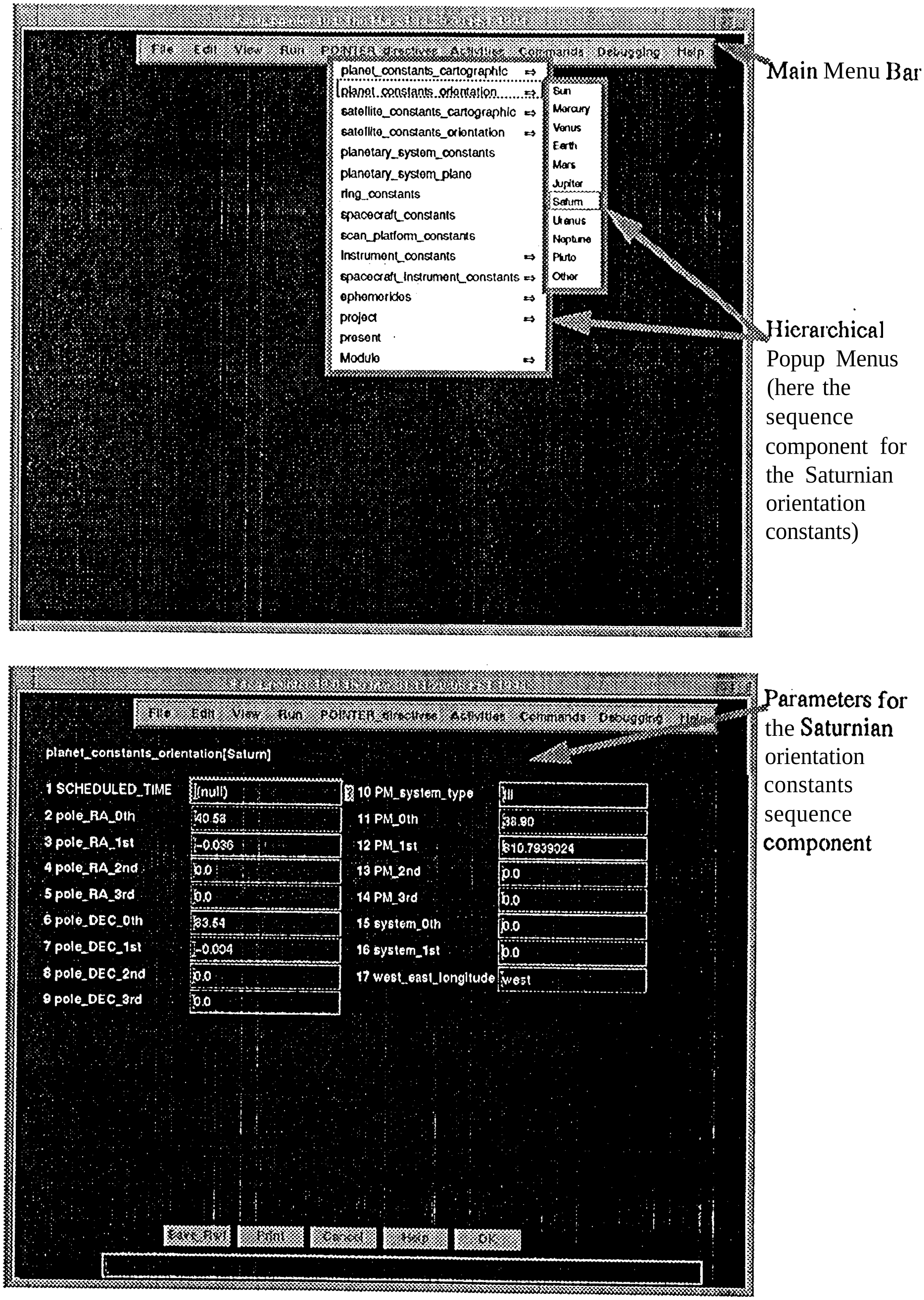

Figure 3. Operator Interface Module - Sample Windows

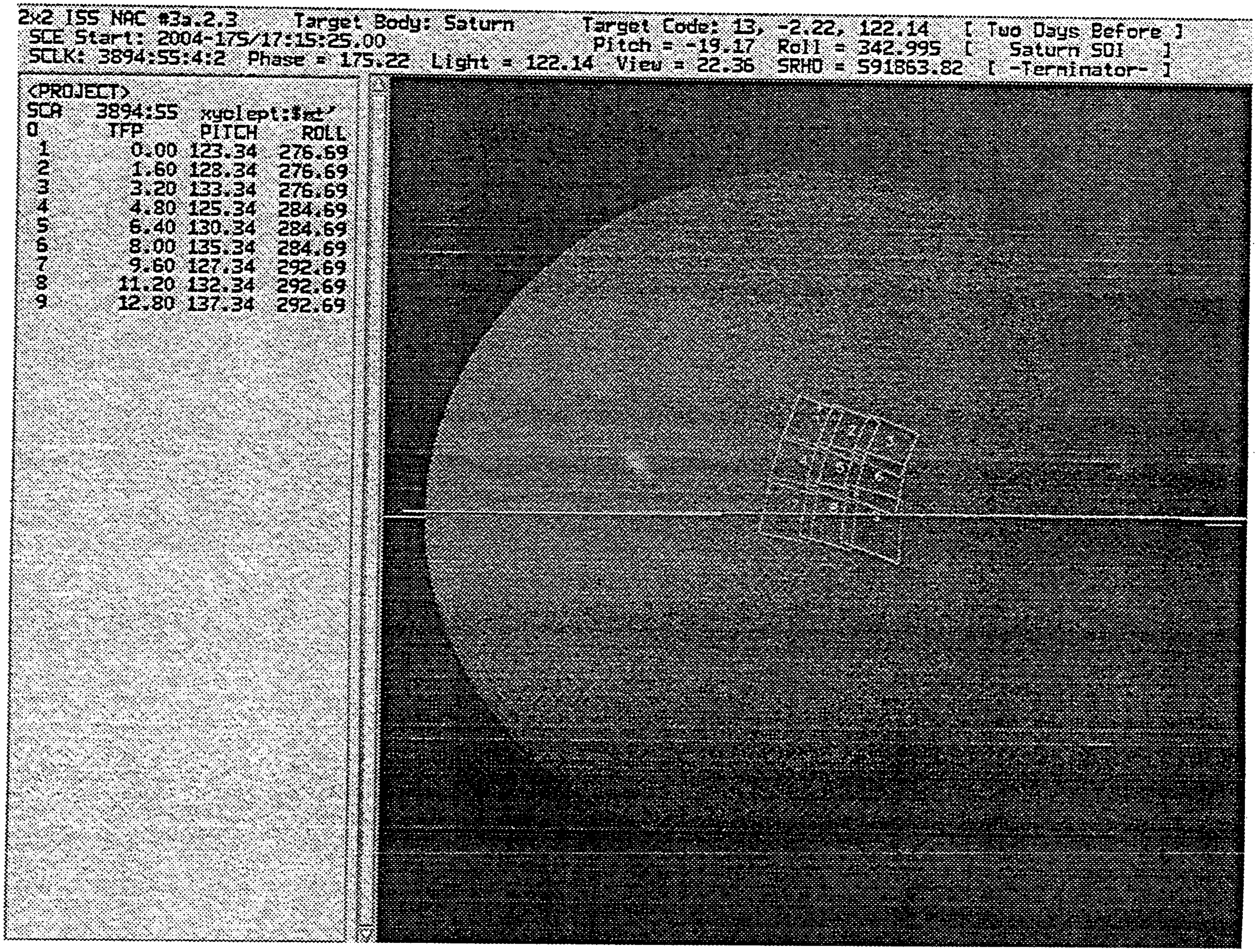

Figure 4. Project Module - Sample Window of an Observation Design Depiction

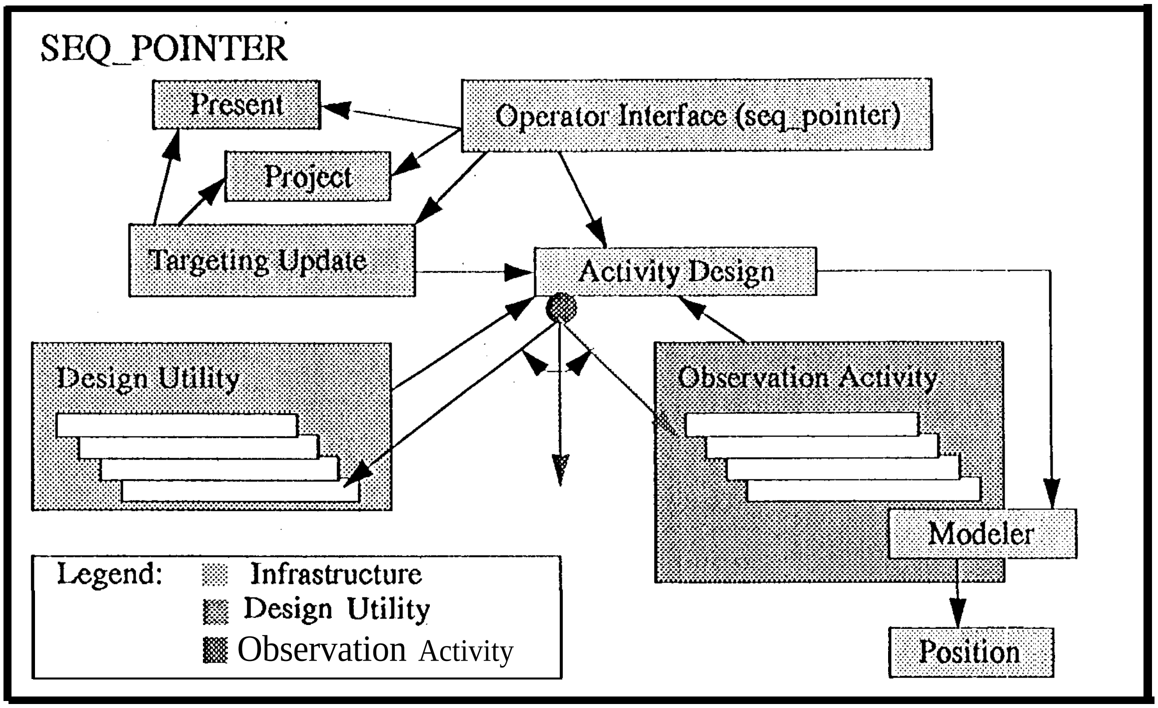

Figure 5. SEQ_POINTER Module Family Architecture

Module Family	Functional Description
Operator Interface	interactive operator and sequence file-request interface
Activity Design	processes observation activities through module families "expanding" activities to the resulting commands
Modeler	calculates spacecraft/scan platform and instrument(s) events from the commands resulting from expansion of the mission dependent activity modules and formats the event data for output
Position	calculates celestial body and spacecraft position data from internal and operator-supplied data or external ephemeris file(s)
Project	graphically depicts the observation events (footprints)
Present	reads the output event data file loading a Lotus 1-2-3 spreadsheet where charts illustrating event data can be output
Targeting Update	batch sequence file processor for updating all observations in the sequence for the latest ephemeris data

Table 1, SEQ_POINTER Infrastructure Module Family Descriptions

designing desired observations. The observation activity program group consists of the module families for all levels of sequence components. The sequence components are expanded to commands and later modeled as the events of an observation.

The tool can be adapted to a new spacecraft because the architecture segregates the mission and spacecraft dependencies. Adaptation is designed into the tool through function modularization and the concept of interchangeable models. The segregation of mission and spacecraft dependencies into independent and dependent module families is illustrated in Figure 6. The independent

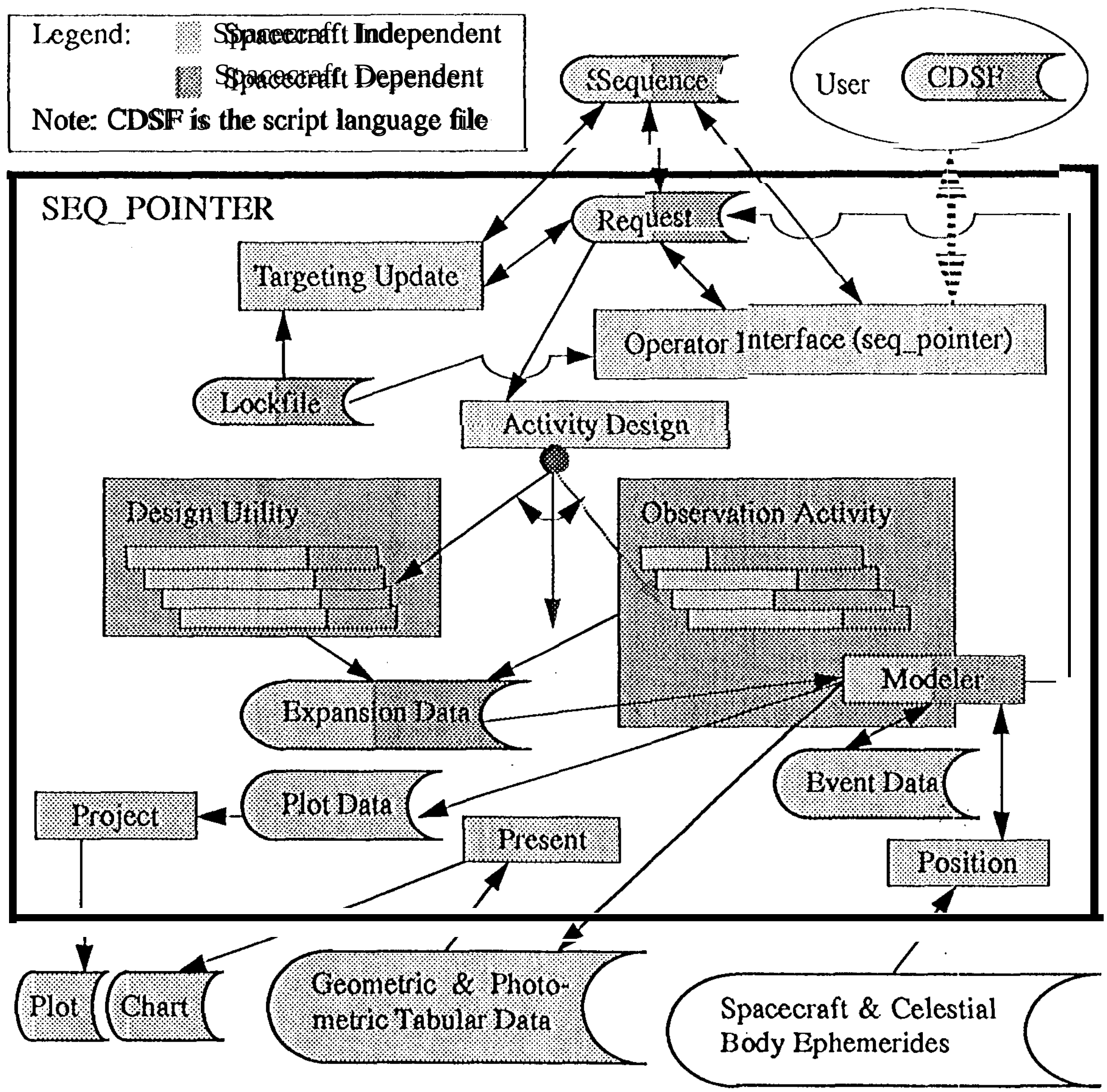

Figure 6. SEQ_POINTER Module-Data Flow

module families read dependent data file(s) to incorporate mission and spacecraft information.

Illustrating interchangeable models, the dependent module families in the design utility and observation activity groups contain both independent and dependent sections. These modules are designed around generic drivers which call plug-in models written in C language functions. The calling and return interfaces are defined for each model family. The model family instance contains or retrieves any model-unique data necessary to calculate the return data,

For example, the interfaces for the celestial body position model family are: as input, the reference (i.e., Sun) and subject (i.e., Saturn) body identifications and the time of the position and, as output, the position and velocity vectors of the subject body relative to the reference body. The interfaces are the same whether the ephemeris data is interpreted from a conic element set, NAIF ephemeris data, or Navigation Team data. Each model instance gathers the data necessary to define the vector set at the input time. For the conic element model, it calculates the vector set from the conic element set and the necessary celestial body constants. For the NAIF or Navigation models, it interpolates the vector set using the ephemeris file readers.

ADAPTATION

Adaptation of SEQ_POINTER for a mission and spacecraft is performed manually. An adaptation utility program provided by another AMMOS tool is planned to be updated, enhanced, and delivered in the future. The following adaptation steps are performed after capability definition to create the mission and spacecraft module suite for the mission specific version of the tool:

1) identification of the necessary models and modules for the mission to be adapted,

2) identification of which existing mission independent models in the model families library satisfactorily provide the necessary capabilities,

3) modification of existing mission independent models in the model families library which must be altered to provide the necessary capabilities,

4) design and creation of new models which must be added to complete provision of the necessary capabilities,

5) design and creation of the sequence components which define spacecraft instructions and translation of the components into a SEQ_POINTER specific file format (Lockfile), and

6) compilation of the mission version models and modules to create the executable module suite.

FUTURE CAPABILITIES

Enhancements to SEQ_POINTER consist of items which were not incorporated during previous development cycles due to technological or resource inadequacies, and items which result from evolution of the mission operations concept. The changes are taking the operations concept from a centralized system using experienced MOS operators to a distributed system where the primary users are scientists and their representatives.

Additions to address the changing environment include enhancements to make the tool more usable by a broader user population and closer association with the spacecraft flight software operation algorithms. Development of a user interface which provides direct graphical manipulation of observation events which are reverse-translated into spacecraft instructions has been proposed, One delayed capability would allow observation design with an irregularly shaped celestial body (e.g., asteroid). A new body surface family model would be developed to access a celestial body digital terrain map for instrument footprint calculations. Also, a new PHIGS data structure translation utility would be included which reads the digital terrain map and produces the data that is used to graphically depict the celestial body with the observation instrument footprint events.

REFERENCE

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