

**University of Michigan
Space Physics Research Laboratory**

TIDI Scan Table Visualization Program	CAGE No.	0TK63
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REVISION RECORD

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APPROVAL RECORD

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1. References

1. Gell, D., "Measurement Sequence Specifications", TIDI File 055-3431, 3 September 1997
2. Gell, D., "Scan Table File Format", TIDI File 055-3527, 22 October 1997
3. Musko, S., "TIDI Flight Software Requirements Specification", TIDI File 055-3320, 15 January 1997

2. Introduction

The operation of the TIDI instrument is controlled by the flight software, which executes an uploadable control program. The control program can load and execute a scan table, which provides all of the information required to define the sequence of states that make up a TIDI scan.

The scan table is the principal means of defining the data collection scheme to be used to meet a particular objective and are defined in a scan table file. As such the scan tables define a sequence of events in space and time. Determining if a scan table meets its scientific objective requires that the analyst insure that the telescopes are pointed at the proper place in the atmosphere, that the filter wheels are in the correct position, and that instrument integration periods are sufficient for the spectral feature being observed. This memo describes a tool VISUALIZE_SCAN that can be used to visualize these relationships.

VISUALIZE_SCAN is a set of IDL functions that the user can invoke interactively or can incorporate in an IDL program or batch file, which will plot the configuration of the instrument as a function of time.

3. Usage

3.1 Program Startup

The scan table visualization program, VISUALIZE_SCAN, is installed on the TIDI MO&DA computer system. To execute the program, start IDL. The command: **visualize_scan**, provides an overview of the Scan Visualization Package (it does not need to be called in order for other commands to work properly.) The main elements allow one to load a scan table from a file, display the configuration of the instrument, the electric current supplied to the filter wheel and telescope motors, and filter wheel motion, and the positions of each mechanism as a function of time.

3.2 Loading a Scan Table

To load a scan table for processing with visualize_scan, you type the following command at the IDL prompt:

```
read_scan, table, info, file="file_name"
```

The first time you invoke this IDL procedure, it will be compiled. In the example, "table" and "info" are the names of the scan table structure and the scan information structure to be created and filled by the function. You supply the name of the scan table file (reference 2) as the value of the keyword parameter file. If you do not supply a file name, you will be prompted for one. If the file does not exist, the routine prints an error message and returns, without initializing the scan table structure, table, or the scan information structure, info.

3.3 Displaying a Scan

To display a previously loaded scan table, you type the following command at the IDL prompt:

```
display_scan, table, info[, /nolegend] [,/notitle] [,
  /print=[dest]] [,/psfile=name]
```

where “table” and “info” are the names of structures you previously filled using read_scan. The optional keyword parameters allow the user to remove the title and/or legend. The user may also chose to print or create a postscript file using one of the last two keywords. The first time that you invoke this IDL procedure it will be compiled.

When you invoke this procedure, it will iconize the previously displayed plot, if any, create a new window, and plot the scan in it. The plot consists of the altitude of each measurement as a function of time, coded by color for the different filter positions. Annotations on the plot include the duration of the scan, from the start of the first sample, to the end of the last, the total exposure time, the duty cycle and the ranges of altitude and elevation angle. Figure 1 contains display of the baseline mode created using the following commands:

```
read_scan, Stable, Sinfo, $
file = '/tidi/flt_ticl/scans/baseline.scan'
display_scan, Stable, Sinfo
```

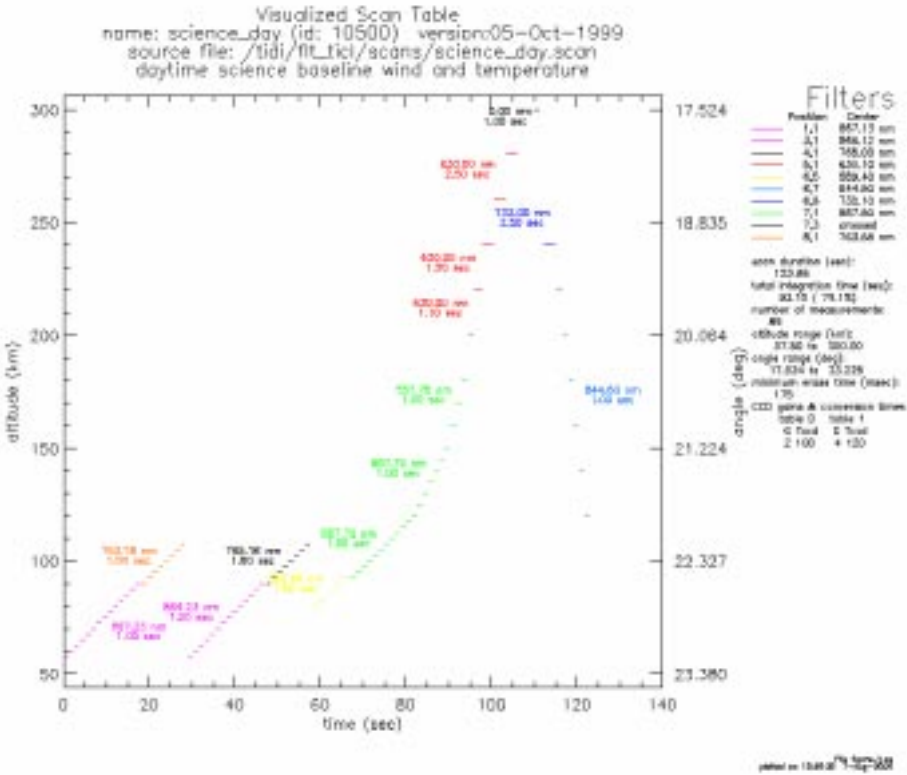


Figure 1, Sample output of the display_scan command

3.4 Displaying Mechanism States

To display the positions of the instrument mechanisms as a function of time, you use the mechanism commands. Once you've loaded the scan table and scan information using the read_scan function, section 3.2, you issue the mechanism command at the IDL prompt:

```
mechanism, table, info
```

where "table" and "info" are the names of structures you previously filled using read_scan. The first time that you invoke this IDL procedure it will be compiled.

When you invoke this procedure, it will iconize the previously displayed plot, if any, create a new window, and plot the time sequence of the mechanism positions in it. The plot consists of four panels, each containing the positions of a different mechanism. The top panel shows the elevation angles of the telescope. The coordinate frame is such that increasing angle corresponds to a decreasing tangent point height. Also shown in additional panels are the filter wheel positions, calibration lamp status, and shutter position. Figure 2 contains display of the baseline mode mechanism positions created using this command.

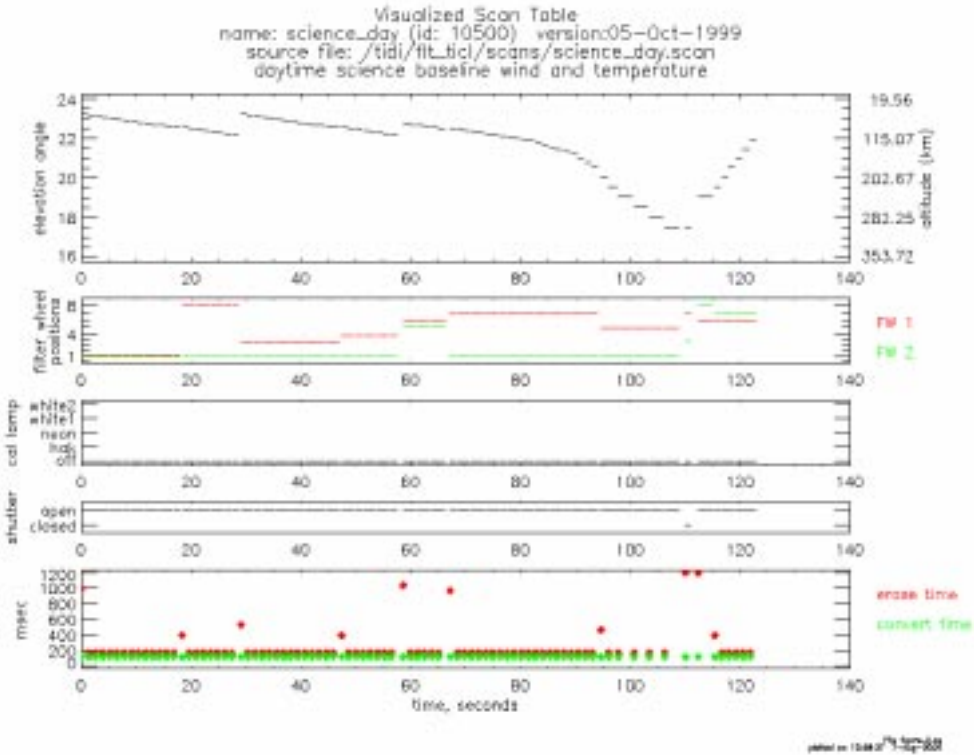


Figure 2, Sample output of the mechanism command

3.5 Displaying the Motor Power

You can display the resources, and electrical power, required to complete a scan by using the resource command. Once you've loaded the scan table and scan information using the read_scan function, section 3.2, you issue the mechanism command at the IDL prompt:

```
resource, table, info
```

where "table" and "info" are the names of structures you previously filled using read_scan. The first time that you invoke this IDL procedure it will be compiled.

When you invoke this procedure, it will iconize the previously displayed plot, if any, create a new window, and plot two panels. The upper panel contains the sum of the telescope actuator and filter wheel motor currents.. The resource plot for the baseline scan is shown in Figure 4. It should be noted that the power required to operate the shutter is uncertain in the current software.

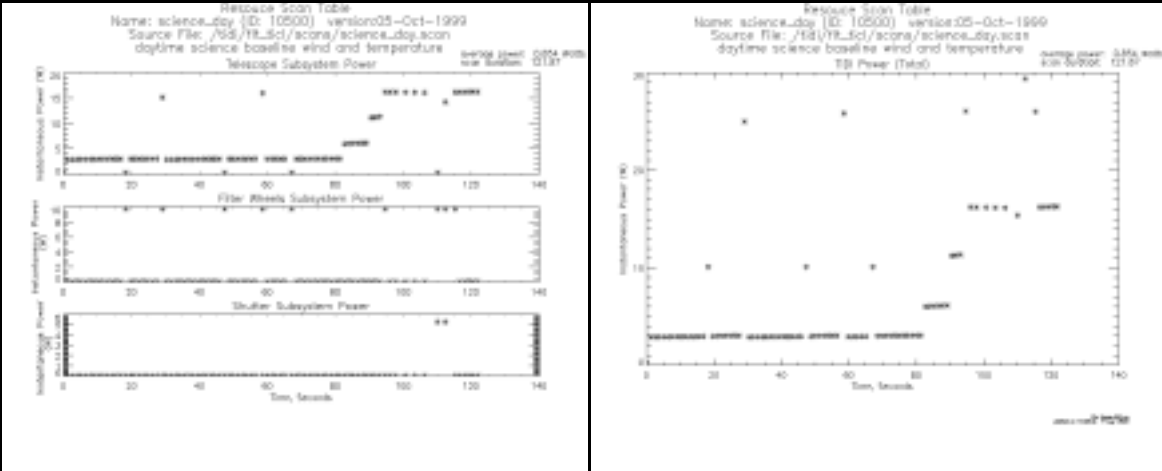


Figure 3a and 3b, Sample output of the resource command

Figure 4a and 3b, Sample output of the resource command

4. Models

The visualize scan package implements simple models to relate the data in the scan tables to altitudes, telescope elevation angles, power utilization and disturbance torques. These models are described in this section.

4.1 Geometry

The telescope elevation scan can be described in the scan table in terms of altitude or elevation angle, as specified by the scan keyword in the file. If the value is altitude, the scan intervals and steps are specified in altitude and the program computes the corresponding elevation angle for the displays. If the value is angle, the scan intervals and steps are specified as elevation angles and the program computes the corresponding altitudes for the displays. The conversions between angle and altitude performed by this program assume that the earth is spherical with a radius of 6378 km and that the spacecraft is in a circular orbit at an altitude of 625 km. The conversions are:

$$h_t = (h_s + R_e) \cos \varepsilon - R_e$$

$$\varepsilon = \arccos\left(\frac{h_t + R_e}{h_s + R_e}\right)$$

where R_e is the radius of the earth, h_s and h_t are the altitudes of the satellite and tangent point, respectively, and ε is the elevation angle.

4.2 Power and Energy

The power displayed in the resource plot is the power supplied to the motors and actuators, and does not include power supply efficiency. The power required by each filter wheel motor is assumed to be 9.8 w while in motion and zero otherwise. The time to required by each filter wheel to move is given in Table 1. The energy required to move the filter wheel is the product of the current and the motion duration.

Table 1, Filter Wheel Motion Duration

filter positions moved step	duration seconds
0	0.143
1	0.143
2	0.202
3	0.247
4	0.286

The program enforces the specification that the filter wheels are not moved simultaneously.

The telescope power is a function of the angular step to be taken. The time, power, energy and torque required for steps of 0., 0.05, 0.10, 0.20, 0.40, 6.30 and 20.0 degrees are specified in a table. Linear Interpolation is used to determine the power required for the actual telescope step. The data used for the telescope model is given in Table 2.

Table 2, Telescope Movement: Duration, Power and Disturbances

Angle deg	time sec	power watts	energy joules	RMS torque N-m
0.00	0.00	0.00	0.0	0.0
0.05	0.10	0.70	0.07001	0.0537
0.10	0.10	1.381	0.1381	0.0111
0.20	0.10	2.596	0.2596	0.193
0.40	0.10	4.087	0.4087	0.262
6.30	0.50	1.450	0.7248	0.137
20.0	1.500	0.6370	0.9552	0.0801

The average power with which the resource plot is annotated is calculated by summing the energy required for all motions and dividing the sum by the duration of the scan.