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Generic Trending and Analysis System

Lori Keehan
Code 511
NASA/GSFC
Greenbelt, MD 20771

Jay Reese
Loral Aerosys
7375 Executive Place
Lanham, MD 20706

ABSTRACT

The Generic Trending and Analysis System (GTAS) is a generic spacecraft performance monitoring tool developed by NASA Code 511 and Loral Aerosys. It is designed to facilitate quick anomaly resolution and trend analysis. Traditionally, the job of off-line analysis has been performed using hardware and software systems developed for real-time spacecraft contacts; then, the systems were supplemented with a collection of tools developed by Flight Operations Team(FOT) members. Since the number of upcoming missions is increasing, NASA can no longer afford to operate in this manner. GTAS improves control center productivity and effectiveness because it provides a generic solution across multiple missions. Thus, GTAS eliminates the need for each individual mission to develop duplicate capabilities. It also allows for more sophisticated tools to be developed because it draws resources from several projects. In addition, the GTAS software system incorporates Commercial Off-The-Shelf Tools Software(COTS) packages and reuses components of other NASA-developed systems wherever possible.

GTAS has incorporated lessons learned from previous missions by involving the users early in the development process. GTAS users took a proactive role in requirements analysis, design, development, and testing. Because of user involvement, several special tools were designed and are now being developed. GTAS users expressed considerable interest in facilitating data collection for long term trending and analysis. As a result, GTAS provides easy access to large volumes of processed telemetry data directly in the control center. The GTAS archival and retrieval capabilities are supported by the integration of optical disk technology and a COTS relational database management system.

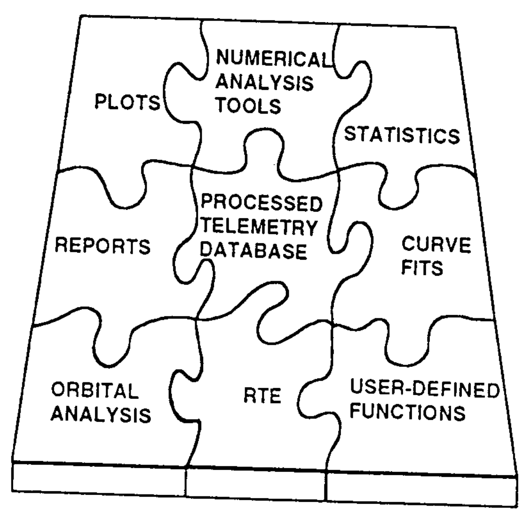

Figure 1: GTAS Pieces

BACKGROUND

Until now, off-line analysis has been performed using collections of tools developed by satellite Flight Operations Team(FOT) members. Separate toolsets have been developed within each project and often by several project members. Collectively, the capabilities of the tools have met the needs of the FOT, but the replication and variance between projects and between FOT members has several drawbacks. Capabilities have been lost when an individual leaves a team or when the FOT contractor is replaced. Similar capabilities were often developed many times, adding to the cost of operations. Since the tools were developed within the constraints of the FOT resources, more sophisticated and efficient tools were not considered. In addition, the task of offline analysis was made more cumbersome because the analysts did not have direct access to processed data. GTAS is being developed to improve this situation.

GTAS METHODS & POLICIES

Constrained budgets and an increasing number of missions force GSFC to evaluate methods for developing and operating systems at a lower cost. GTAS is an example of this process improvement. First, the GTAS project is being developed to meet the needs of multiple current and future missions. It draws cross project support, promotes the sharing of technology, and attempts to eliminate the development of duplicate capabilities. It uses lessons learned from previous mission experience and it generates a forum for cross mission contact.

Second, it takes the task of generating off-line analysis tools away from each individual FOT member and gives it to individuals who are trained in control center development. Thus, primary off-line analysis tools are no longer expected to be developed separately by each end user in his free time; rather, they are an inherent part of the control center system.

Third, GTAS attempts to take advantage of Commercial Off-The-Shelf Tools (COTS) software packages and reuses components of other NASA-developed systems. COTS products are extremely powerful and provide a cost-effective method for meeting many missions requirements. Currently, GTAS uses a plotting and analytical software package called PVWAVE, a optical jukebox file management software package called AMASS, and the ORACLE relational database system. In addition, GTAS integrated TOSA, an existing NASA developed project, into its delivery. This product provides the end-user the ability to monitor time-varying parameters based on signature analysis and orbital events.

ENVIRONMENT

GTAS is developed within the Transportable Payload Operations Control Center (TPOCC) environment. GTAS is being used or is planned to be used by the following projects: Fast Auroral Snapshot Explorer(FAST), Submillimeter Wave Astronomy Satellite (SWAS), WIND, Polar Plasma Laboratory (POLAR), Solar and Heliospheric Observatory(SOHO), X-Ray Timing Explorer (XTE),
Advance Composition Explorer(ACE), Tropical Rainfall Measuring Mission (TRMM), and Far Ultraviolet Spectroscopic Explorer (FUSE).

The TPOCC systems utilize UNIX workstations, X-terminals, and VME-bus systems connected via a local area network.

The TPOCC Front End Processor(FEP) processes data in real-time. Its sources of input are mission dependent, but they commonly include NASCOM blocks, CCSDS frames, Data Capture Facility's Packet Processor (PACOR)files, and telemetry history files. Each Mission Operations Center(MOC) development task is responsible for developing a Real-time processing capability. Real-time processing and replay are functionally identical. Therefore GTAS uses the output to the MOC processing as the source of its input. Thereby, eliminating the development of duplicate functionality.

IMPLEMENTATION

Resolving some spacecraft anomalies in the control center is like looking for the proverbial needle in a haystack for the spacecraft analysts. They must survey large volumes of data to find one byte of information that caused the anomalous situation. GTAS provides the following features to assist the spacecraft analysts in their search: statistics, relational telemetry expressions, plotting and mathematical tools, and an archival and retrieval system.

Statistics

GTAS routinely ingests subsets of telemetry data and creates statistical data sets. Statistics are stored with both long and short term granularities; users may select to generate statistics in millisecond, second, hourly, daily, orbital, or user-defined intervals. For analysis using plots, statistical reduction has the advantage of tremendous efficiency savings without the drawbacks associated with data thinning or interval sampling. For generating a long period assessment of the spacecraft's performance, a plot of the parameter's statistics provides a quicker and more readable end product. For example, a full 24-hour period contains 1440 one-minute statistical data points versus over one million points without statistical reduction. Figure 2 displays the graphical user interface used to select a parameter's statistical intervals.

Relational Telemetry Expression

Previous mission analysts have expressed a need to facilitate data collection to support anomaly detection and trend analysis. GTAS provides an event-driven data capture tool called a Relational Telemetry Expression (RTE). It will capture subsets of processed data to support analysis. A RTE is a triad consisting of the set of user-defined telemetry conditions, an evaluation criteria, and a list of mnemonics to output when the conditions are met. The

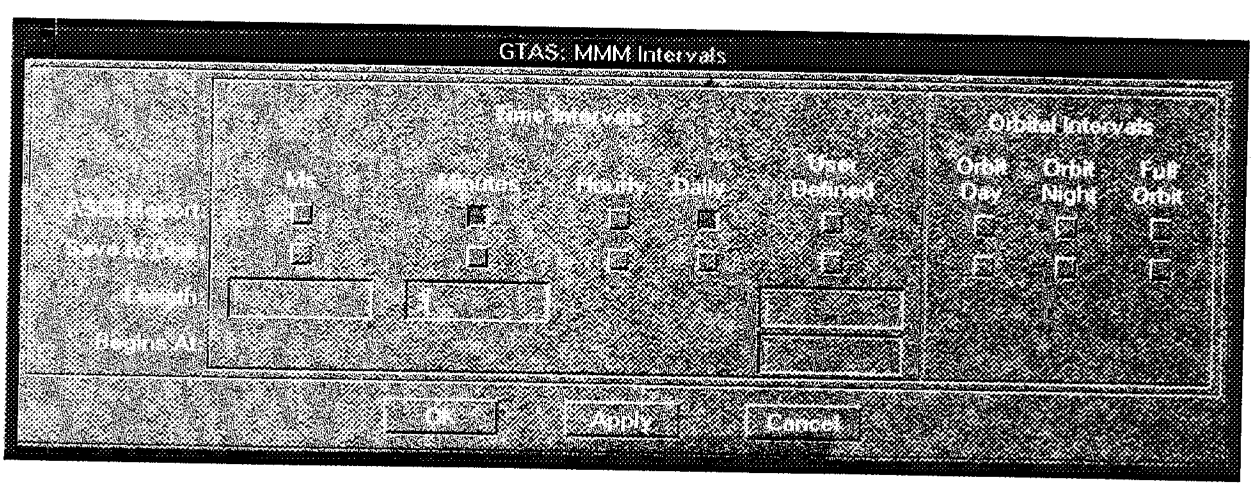

Figure 2: GUI to Select Statistical Intervals

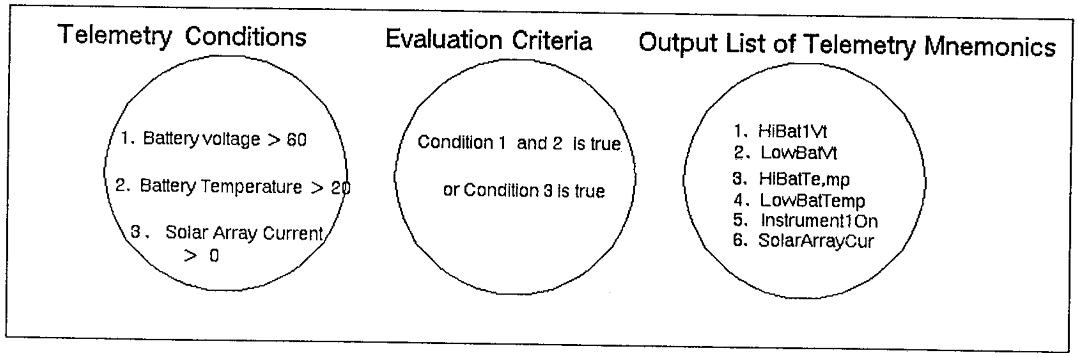

Figure 3: Sample Content of an RTE Expression

RTE task evaluates the user-defined conditions based on the evaluation criteria, then outputs the list of related mnemonic values. True or false values of RTEs are written to an output file, and upon request, ingested into the trending database. The results of this RTE are used to evaluate broader boolean equations then are used to evaluate a particular spacecraft state by the real-time system. Figure 3 shows the contents of a sample RTE expression.

Plotting and Numerical Analysis

GTAS plots provides users with a multi-dimensional visualization tool. It uses advanced graphical techniques to accelerate the search for patterns and trends in large technical datasets. Several types of common plot output are telemetry vs. time, telemetry vs. telemetry, statistics vs. telemetry, statistics vs. time, statistics vs. statistics, RTE vs time, RTE vs. RTE, and RTE vs statistics. The key to the GTAS plotting software is its flexibility. Users may plot in portrait or landscape mode, display multiple plots per page, choose grid options, choose axis lengths, select the number of tickmarks, specify the length of the tickmarks, annotate text directly on the plot, zoom in or out of the plot, etc. A sample plot is pictured in Figure 4.

In addition to the plotting tools, GTAS gives the user access to hundreds of numerical library functions such as fast fourier transforms and curve fitting routines. It also provides convenient access to these numerical tools directly from the plots. Reference 6 contains a complete listing of GTAS plotting and numerical analysis capabilities.

Archival & retrieval

Traditionally, the task of offline analysis was extremely cumbersome because the end users did not have direct access to processed historical data. They were forced to rely on outside individuals to retrieve raw historical data. These data retrievals could take anywhere from several days to several weeks; some older data was virtually impossible to retrieve at all. Once the data was retrieved, it needed to be processed. This task could also be very time consuming, especially if realtime resources could only be scheduled during non-contact periods.

GTAS, however, archives processed data directly in the control center for easier access to the end user. To do this, GTAS integrated a optical disk mass storage system with its trending database. The system is capable of storing over 40 GB online. This

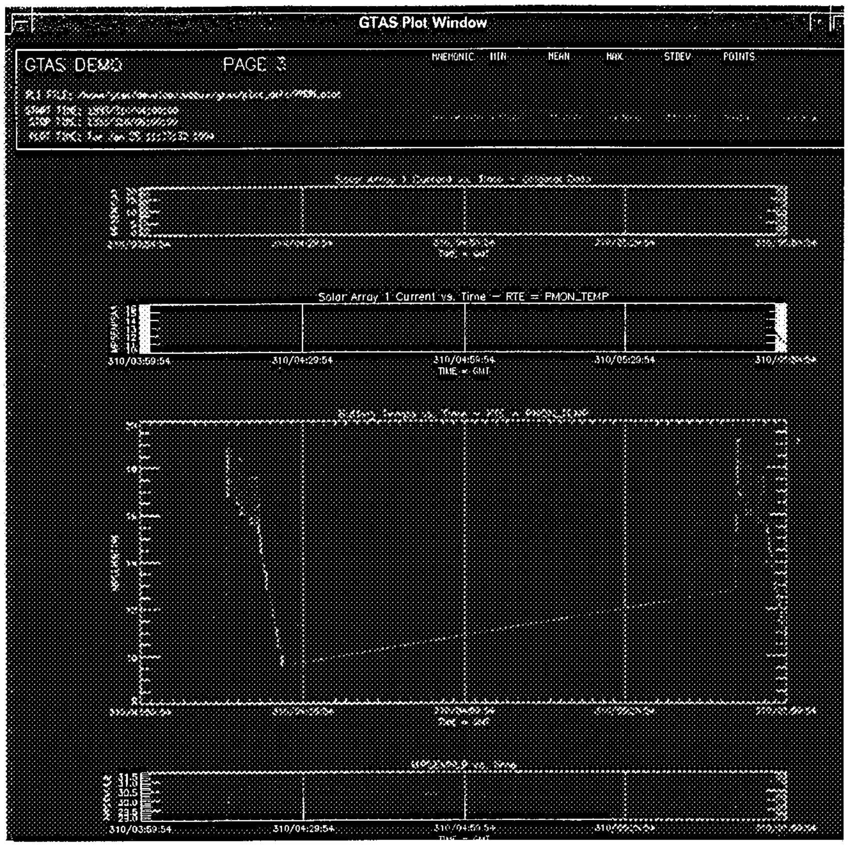

Figure 4: Sample Plot

provides a library of approximately 30 days of subsetted telemetry directly in the control center. Plus, data retrievals no longer require outside intervention and retrieval times are reduced from weeks to minutes.

The GTAS archival and retrieval system also provides a data editor capability. This will allow the users to do "what-if" analysis while also maintaining data integrity. Only privileged users will be allowed to make permanent changes to the data in the database. All other users will have direct access to the data and may manipulate and categorize the data as they see fit without effect to the mission's trending database.

REFERENCES

1). Computer Sciences Corporation and Integral System, Inc., *Transportable Payload Operations Control Center (TPOCC) Generic User's Guide*, (Revision 2), September, 1991.

2). NASA, *Generic Trending and Analysis Workstation Design Concepts Document*, Version 2.0, January 1993

3). Loral Aerosys, *Generic Trending and Analysis System(GTAS) System Requirements Document(SRD)*, June 1993

4). Loral Aerosys, *Generic Trending and Analysis System(GTAS)* Detailed Design

Specification(DDS), April 1994

5). Loral Aerosys, *Generic Trending and Analysis System(GTAS) Release 1 User's*

6). Visual Numerics Inc, *Command Language Reference Volume 1 & 2,* 1993