Real-time Attitude on the Web (RAW)

by
Sheela V. Belur
Computer Scientist
Computer Sciences Corporation

Category:
Aerospace/Defense

Products Used:
LabVIEW™
Internet Developers' Toolkit

The Challenge:
Real-time Spacecraft Attitude Determination and Monitoring via the Web.

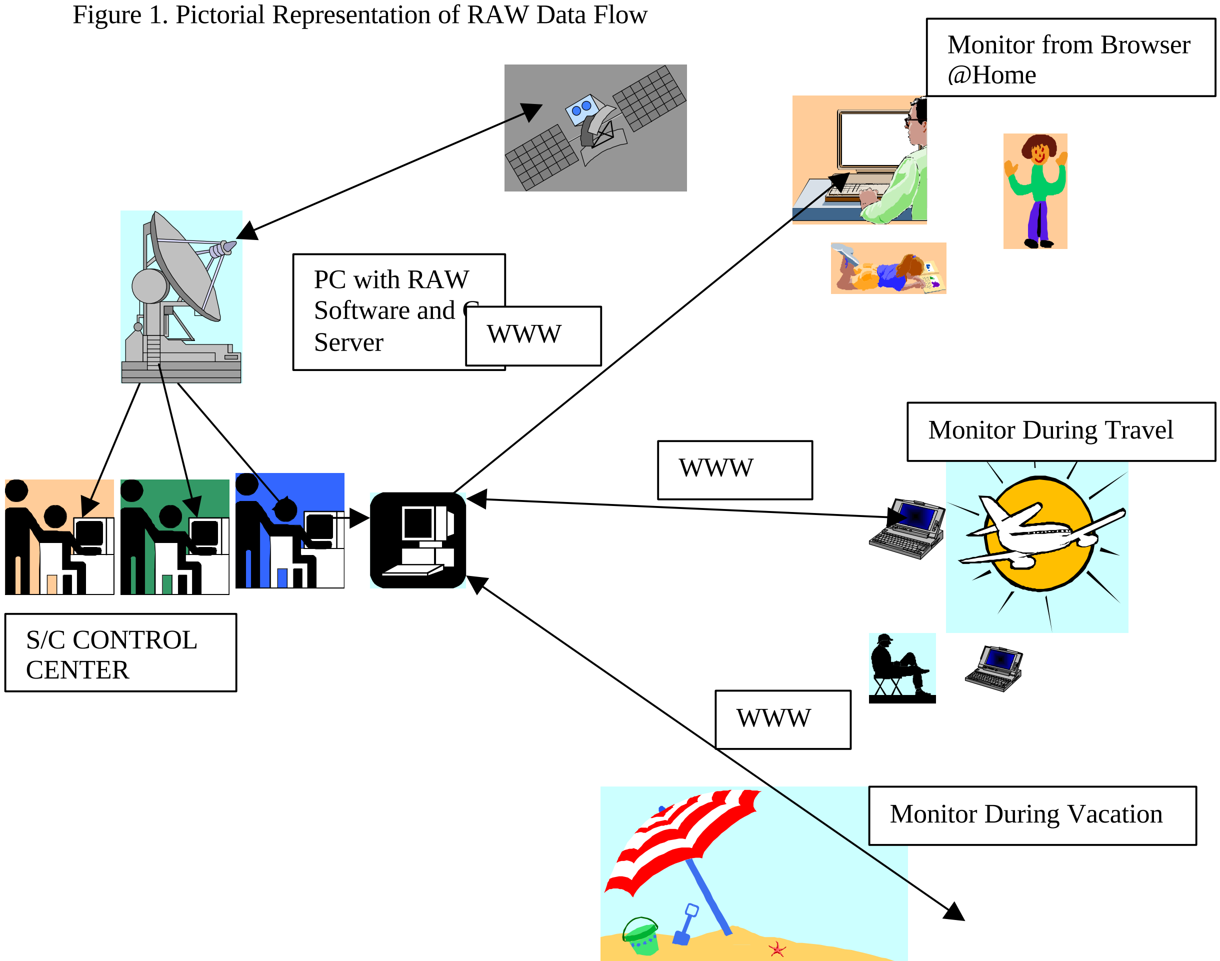
The Solution:
LabVIEW for telemetry data acquisition, sensor data preprocessing and attitude determination; Internet Developers' Toolkit to provide interactive monitoring via the Web browser.

Introduction:
Real-time spacecraft attitude determination essentially involves estimation of the orientation of the spacecraft in space using the sensor data as it is being telemetered to the ground from the spacecraft. This is very important in the early-mission phase in order to make sure that the spacecraft is oriented in the desired way and that all attitude sensors are operational. During this phase, the spacecraft analysts usually monitor the real-time attitude determination being run at the control center. Real-time attitude determination was one of the flight dynamics functionalities that LabVIEW was evaluated for, early in 1998 under a NASA task on Commercial Off-the-Shelf (COTS) product evaluation and integration. At that time, a prototype for real-time spacecraft attitude determination system (RTADS) was built in LabVIEW. The current version, built specific to X-ray Timing Explorer (XTE) spacecraft, is capable of handling magnetometer, Sun and star tracker data and displays the estimated real-time attitude data and its comparison with the on-board estimated and telemetered attitude data in text as well as real-time graphical plots.

Real-time Attitude on the Web (RAW) Prototype
Recently the Computer Sciences Corporation (CSC) Leading Edge Forum (LEF) awarded a technology grant to the author to carry out research work in the area of real-time data rendering over the Internet in response to her proposal for building a real-time spacecraft attitude determination prototype using National Instruments products. The aim of the short-term LEF grants is to explore technology topics or solutions that are currently gaining momentum in the market and leverage them to benefit CSC. The existing real-time attitude determination system RTADS outlined above was web-enabled using the Internet Developers ' Toolkit under this short-term project in a record time due to the plug and play feature of the National Instruments' products.

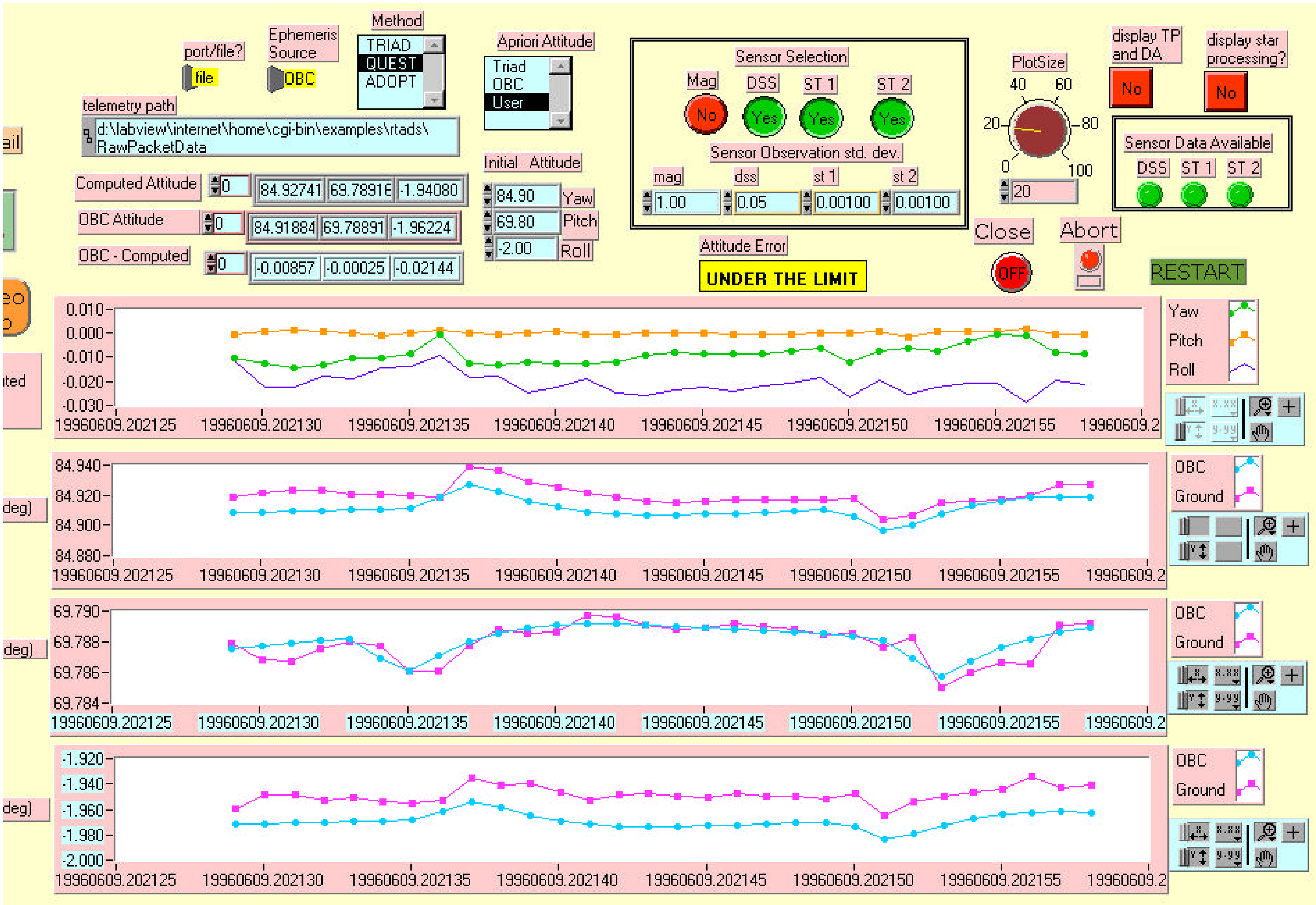
The author used National Instruments' Internet developers' toolkit to web-enable the RTADS prototype and established the feasibility of interactive monitoring by spacecraft analysts via third-party browsers. The Web-enabled prototype called RAW (Real-time Attitude on the Web) in its current form reads spacecraft telemetry data from a file on hard disk of the workstation on which it resides. Figure 1 shows the pictorial representation of RAW data flow.

Figure 1. Pictorial Representation of RAW Data Flow



The major functional steps of the RTADS prototype include extraction of relevant sensor data from among magnetometer, digital sun sensor and two star trackers, conversion to engineering units and generation of 'observation vectors' and transformation to body coordinates. If star tracker is a selected sensor, star identification is carried out using a priori attitude and reference vectors are generated and finally attitude determination is carried out and the results are displayed on the front panel as text and as graphical plots.
Figure 2 shows the front panel of RAW when it is being run.

Figure 2. Front Panel of RAW When Being Run



The Web interface is accomplished using the G Web server and its built-in functions in conjunction with html documents. National Instruments provided virtual instrument (VI) called VI-CTRl.VI to control custom VIs was very helpful in minimizing the CGI programming effort involved in Web-enabling. Most of the browser-based input controls were accomplished using this VI in conjunction with image maps. The Web document also embeds video help, audio help and email buttons activated using JavaScript.

Some of the features of the prototype are:

- Restricted access:
  Access to the front panels and chosen sub-directories are restricted using username and passwords, which were configured without any programming effort using windows-like interface. IP address based restrictions are also incorporated in the same way.
- Browser-based inputs:
  Several user-selectable browser-based inputs are provided such as mode of TLM /Ephemeris data, type of estimation method, sensor selection and standard deviation, mode of *a priori* attitude, *a priori* attitude and plot size. Additionally, browser-based controls for stopping, closing the front panel and restarting the program.
- Visual and e-mail alarms :
  Visual and email alarms are provided which are activated when the error between estimated attitude angles and the telemetered on-board attitude angles exceed a pre-set threshold.
- Multiple component types:
  The system has both LabVIEW and MATLAB[™] components. Existing MATLAB components were easily incorporated using MATLAB script nodes without having to re-code.
- On-line visual and audio help files:
  Audio and video help files to aid browser-input interface embedded into the html document and activated using JavaScript.

To sum up, some of the advantages of this approach are:

- Offers off-site monitoring
- Involves little programming effort
- Legacy modules in other programming languages can be incorporated and web enabled
- Can be served from workstations on which LabVIEW is not installed if a stand-alone executable is built and shipped.

Some of the scenarios where such systems can be put to use are for spacecraft monitoring and control for low-cost constellation missions that can not afford spacecraft-specific control centers and for remote access by payload scientists at universities and international institutions.

Acknowledgements
The author thanks are due to the CSC Leading Edge Forum for providing the technology grant to carry out this work and the LEF Director Mr. Paul Gustafson, in particular, for his encouragement and support during the course of this work. The author is grateful to Dr. Dipak Oza and Dr.Avinash Beri for relieving the author of her regular work during this time to carry out the special assignment. Finally the author acknowledges the efforts of Mr. Dan Kulp, Mr. Seth Shulman and Mr. John Landis who were responsible for the original version of the RTADS prototype.

[™] MATLAB is a trademark of Mathworks, Inc.