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Title: COMPUTERS AND SMALL SATELLITES: HOW FORTÉ IS UTILIZING THE WWW AS A "PAPERLESS" INFORMATION RESOURCE AND THE DEVELOPMENT OF A UNIQUE RESOURCE MANAGEMENT PLANNING TOOL

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Computers and Small Satellites: How FORTE is Utilizing the WWW as a "Paperless" Information Resource and the Development of a Unique Resource Management Planning Tool

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Abstract. The Fast On-orbit Recording of Transient Events (FORTE) satellite is the second satellite to be developed and flown by Los Alamos National Laboratory and is scheduled to be launched August, 1997 by a Pegasus XL rocket. FORTE follows in the footsteps of the ALEXIS satellite in utilizing a very small operations crew for mission operations. Partially based upon the ALEXIS automation and World Wide Web (WWW) usage for data dissemination, FORTE began at an early stage of ground processing to use the web as a repository of information about all aspects of the satellite. Detailed descriptions of the various satellite and experiment components, cable diagrams, integration photographs as well as extensive test data have all been complied into a single site as a means of archiving the data at a single location. In this manner, it is readily available during times of ground testing, ground station operation training as well as anomaly resolution.

Small satellites usually require extensive effort to optimize operation under minimal resources. For the FORTE satellite, a unique planning tool has been developed over the past 2 years which balances the various resources of the satellite (power, memory, downlink, on board command buffer, etc.) to provide the maximum data acquisition. This paper will concentrate on a description of both the extensive web interface and the planning tool.

Introduction

Fast On-orbit Recording of Transient Events (FORTE) satellite (as discussed elsewhere in this conference by S. Knox) is the second satellite to be developed by Los Alamos National Laboratory. FORTE is a joint effort between Los Alamos National Laboratory (LANL) and Sandia National Laboratory (SNL). The launch and launch services are being provided by USAF SMC/TE. FORTE is scheduled to be launched late August, 1997 by a Pegasus XL rocket. FORTE is comprised of two experiments: an ultra-sensitive radio frequency receiver/digitizer and an optical lightning sensor.

FORTE follows in the footsteps of the ALEXIS[1,2,3] satellite in utilizing a very small, skunk works team for development, fabrication and payload processing (less than 40 full-time people) and a very small operations crew for mission operations[4] (less than 10 full-time people). LANL is the lead laboratory in charge

of program management, the radio frequency experiment, spacecraft bus development and spacecraft integration and testing. SNL has responsibility for the power control unit (PCU), the high speed data formatter, the optical lightning sensor (OLS), the adaptive pre-whitening filter (APW), the ground tracking facility and tracking operations. This paper will concentrate on a description of both the extensive web interface that has been developed as a "paperless" archive of information and a planning tool which is still in development and hopes to balance the various resources of the satellite (power, memory, downlink, on board command buffer, etc.) to provide the maximum data acquisition.

FORTE and the WWW

Early in the program, there was concern about adequate information dissemination and data archive both because of the small skunk works nature of the project which by its nature results in minimal documentation and because of the multi-institutional nature of the project and the physical distance between the laboratories involved. This separation is a problem initially between the various groups developing and integrating the hardware and eventually between RF payload users at LANL and the ground station operators at SNL. Partially based upon the success of the ALEXIS automation and World Wide Web usage[5] for data dissemination, FORTE began at an early stage of ground processing to use the Web as a repository of information about all aspects of the satellite[6]. Since initially designed, the Web site has developed into a location for use as a common archive of data and information that it is immediately accessible for use by both organizations and the Air Force launch teams.

The FORTE web site is comprised of 2 major parts, an external viewable segment and a larger, for internal use only and protected segment. The externally viewable pages are intended for use by both the project and the general public as a means of public outreach. It contains a brief introduction of the project, a listing of (and when available PDF files) of the papers or articles that have been published on many aspects of the project, and a photo gallery displaying all aspects of the satellite project. In addition, a special page was developed which displayed a real-time web camera image of the testing for use during the February solar panel in-the-Sun test to enable team members to watch the testing from the comforts of their offices. Recently, a page was added to display the integration to the PEGASUS rocket during final preparations at Vandenberg Air Force Base.

Because of the sensitive and potential proprietary nature of the project information, the major amount of detailed FORTE information is contained on internal use only pages. This area, containing a wealth of information from the project phone book to detailed cable layout diagrams, is for archiving project data and as a reference/training document for the ground station operators. In this way, a significant amount of information will be kept readily available for use in a single location long after the original engineers and staff gone on to new projects taking their log books and plots of test results with them. This means of document control also eliminates the concern about whether "paper" documentation is up-to-date or whether change pages need to be included, etc.

The major segments of the internal use only section are the address book with phone numbers as well as e-mail addresses, cable and signal diagrams, block diagrams of the various components, detailed discussions on operations of the power control unit (PCU), the batteries, attitude control hardware, and the radio frequency (RF) experiment including environmental test results. There is also an archive library for project report deposition with a perl script engine that will search both internal only and external papers on a particular category or by author. This archive library was written by and adapted for use by FORTE by Mr. Peter Ratzlaff, a former ALEXIS graduate student. The early mission operational timeline as well as detailed early mission satellite contact "scripts" are also available for comment by the entire team as well as nominal and off-nominal procedures for the flight operations team. Detailed data structure information as well as state-of-health monitors are also listed along with minimum and maximum value information. High level descriptions of the

software available to process the data are also listed.

The above mentioned web pages are static; once written, only minimal changes are made as necessary. Other web pages are programmatically generated. For example, a spacecraft and payload command reference is generated from the command definition tables that are used to operate the satellite. A perl script is run hourly to parse the command definitions and create the HTML documents. This method provides a self-documenting system that assures the reference is up-to-date.

Once FORTE is on-orbit and collecting data, the web will be used to archive summary e-mail information about the most recent satellite contacts.

FORTE Planning Tool

The FORTE satellite will do extensive world-wide survey experiments over a wide range of local time, and seasonal conditions. Although FORTE is a nadir pointed satellite and thus will not require detailed planning that a mission similar to Space Telescope would require, there are several consumables that need to be minimized in order to maximize the science potential.

Among the "consumables" for FORTE are:

1) Total Downlink Capability. The nominal downlink rate will be 2 megabits per second with lesser rates available if the link margin found to is a problem once on orbit. The average total time per day that the satellite will be in contact with the ground station is 35 minutes.
2) Available Science Data Memory. The RF experiment has 160 MB available for science data storage. Each individual RF experiment will use between 4K Bytes and 160M Bytes of memory with the average size being 200K Bytes. the Optical Lightning Sensor (OLS) has 2 MB of data storage available which will hold 16K events. The APW has 1 MB of data storage available.
3) Battery Capacity. FORTE has two 7.5 amp-hr batteries which will be cycled between 80-100% full to maximize the lifetime of the batteries. Because the satellite is nadir pointed and there are no maneuverable solar panels, the power profile during the daylight portion of the orbit varies between 90-300 watts. Several of the experiment configurations draw 4.5-5.5 amps which is not sustainable except for short durations.
4) Stored Command Queue Length. There are 4 command queues on the FORTE satellite, 1) spacecraft which can hold 200 commands, 2) RF which can hold 700 or configurations for 40 separate experiments each of which can result several hundreds of events and 3) OLS which can hold 1,000 commands or hundreds of configurations and 4) APW which can hold 100 commands.

A planning tool is being developed to help maximize the scientific "bang for the buck" while keeping within the above stated constraints. Ultimately, the planning tool will be able to propagate the next few days satellite ephemeris, determine which ground target locations will be visible, prioritize the targets based upon experiment requirements and past observability via a data base search, and determine the "consumable" usage. The current state of the planning tool is that the main power consumption segment which has been developed to closely model the on-board power control unit with high fidelity has been written. Also a top level widget interface has been constructed which will display the available ground targets and add them to a command queue for later sorting with the list derived from the ephemeris propagated list of available targets. Still in the development stages, it is hoped that the tool will be finished soon after launch.

Summary

In this paper we have presented the efforts to provide the FORTE project "on-line" documentation as a means of moving towards a "paperless project" and as a means of creating a single depository of project data. Overall, the FORTE web page has become a valuable resource. Not everything is linked to this page yet, but there is sufficient data for a general overview or quick look-up. The success of the FORTE Web project has highlighted the

shortcoming of its client-server nature. Users requesting information from the web site are dependent on the robustness of the server and the local area network. Our computing environment is highly distributed, with two NFS file stores serving user accounts, applications and project space to over 90 UNIX workstations, including the web server. While outages are rare, their occurrence has lead to the phrase "live by the net, die by the net."

During the final months of testing at SNL and integration with the launch vehicle at VAFB, the web site was cloned to standalone machines that were taken to the field. This assured fast access to the documentation when internet access was not available or limited to modem speeds.

A unique planning tool is also under development to help optimize the science yield while working under moderately severe mission "consumables". The top level interface and the high fidelity power control unit model have been completed to-date and it is hoped that the full tool will be available a month or two after launch.

Acknowledgments

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References

1. W. C. Priedhorsky, et al., 1988, " ALEXIS: An Ultrasoft X-Ray Monitor Experiment Using Miniature Satellite Technology", 154-164, SPIE Vol. **1344** EUV, X-Ray, and Gamma-ray Instrumentation for Astronomy (1988).

2. W. C. Priedhorsky, J.J. Bloch, E.P. Wallin, W.T. Armstrong, O. H.W. Siegmund, J. Griffee and R. Fleeter, 1993, "The ALEXIS Small Satellite Project: Better, Faster, Cheaper Faces Reality", IEEE Trans. Nucl. Sci.

3. W. C. Priedhorsky,J.J. Bloch, D.H Holden, D.C. Roussel-Dupré,B. W. Smith, R. Dingler, R. Warner, G. Huffman, R. Miller, R. Dill, and R. Fleeter., 1993, "The ALEXIS Small Satellite Project: Intiial Flight Results", 114-127, SPIE Vol. **2006** EUV, X-Ray, and Gamma-ray Instrumentation for Astronomy (1993).

4. D. Roussel-Dupré, J.J. Bloch, D. Ciskowski, R. Dingler, C. Little, M. Kennison, W. C. Priedhorsky, S. Ryan and R. Warner, "On-Orbit Science in a Small Package: Managing the Alexis Satellite and Experiments", SPIE **2267**, 76, 1994

5. http://nis-www/nis-projects/alexis

6. http://nis-www/nis-projects/forte

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