AIRSAR Automated Web-based Data Processing and Distribution System

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Abstract- **In this paper, we present an integrated, end-to-end synthetic aperture radar (SAR) processing system that accepts data processing requests, submits processing jobs, performs quality analysis, delivers and archives processed data. This fully automated SAR processing system utilizes database and internet/intranet web technologies to allow external users to browse and submit data processing requests and receive processed data. It is a cost-effective way to manage a robust SAR processing and archival system. The integration of these functions has reduced operator errors and increased processor throughput dramatically.**

I. INTRODUCTION

The NASA/JPL Airborne Synthetic Aperture Radar (AIRSAR) has acquired data for a large and varied community of scientists and engineers for 16 years. AIRSAR data are currently collected for NASA investigators in the United States such as for the Soil Moisture Experiment and the Cold Land Processes experiment, as well as research sponsors from international organizations. During the past 10 years, its processing, data ordering, and delivery system has undergone evolutionary changes as the cost and capability of computer resources have improved.

AIRSAR now has a fully integrated data acquisition, user request, data processing, quality assurance, archiving, and delivery system where communication between the processor components is accomplished by sharing information in a common database[1].

The AIRSAR system is a three-frequency airborne SAR system that was developed as a versatile test-bed for radar technology and advanced SAR imaging techniques including fully polarimetric[2], cross-track and along-track SAR interferometry[3]. The AIRSAR data processing subsystem is used to automatically generate co-registered multi-frequency (C-, L-, and P-band) images from both polarimetric and interferometric data collection modes in 80/40/20 MHz bandwidth. If the Digital Elevation Map (DEM) can be generated using the C-band or L-band interferometric data, then the other data channels are projected onto the ground plane using that DEM.

II. SYSTEM FUNCTIONAL DIAGRAM

The AIRSAR data processing automation system is shown in Fig. 1. It consists of five major components: IT Data Servers, Queue Management Intranet Service, Survey Image Automated Data Processing, Precision Image Automated Data Processing, and High-speed Raw Data Tape transfer subsystem. The IT Data Servers are composed of three web servers, two map servers, one image archive server, and two Oracle database servers. Both web servers and map servers are based on a load-balanced mechanism implementation to share the traffic load of the web browser's requests. The map server provides a global map to allow a user to search for any mission flight line by entering

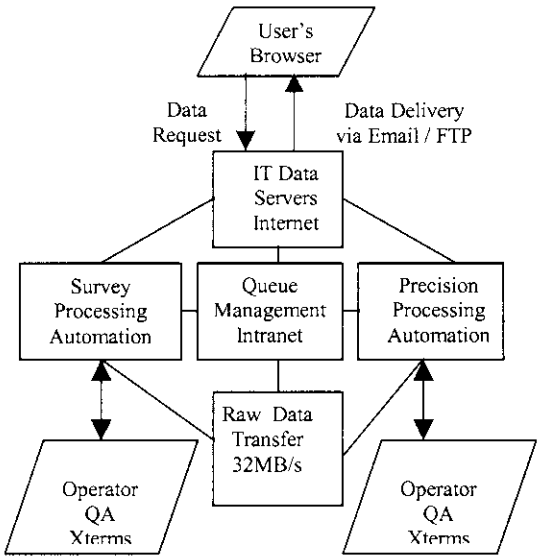

Figure 1. System Functional Diagram

the desired latitude and longitude, and make a data processing request or a processed data duplication request in user-friendly way. The image archive server holds all Survey and Precision images managed by the Oracle database. A primary Oracle database and a hot backup Oracle database form the Oracle database subsystem. In order to incorporate the IT Data Servers subsystem with the Survey and Precision data processing subsystem, the Queue Management Intranet Server provides an interface via shared information within a database. Five SGIs hosts with sixty-two CPUs support the daily Precision and Survey data processing activities.

III. SURVEY AUTOMATION PROCESSING

The Survey image provides target locations for a data processing request. The user can use target location to order a mosaic of images with multiple flight lines requests. A Survey image shows the entire flight line processed to a low resolution un-calibrated browse product. The survey image can be completed and posted on the web site (http://airsar.jpl.nasa.gov) by the time the AIRSAR instrument returns to JPL by simply shipping AIRSAR data via airfreight back to JPL during the mission. The Survey processing involves a 32 MB/sec high-speed raw data tape transfer [4] and an unfocused SAR processor. The Survey processing first scans the raw data tape to identify a valid flight line before download the data to disk to generate the Survey images and archive it into the database. The Survey image generation is an over-night process to generate Survey images for an entire 90 GB raw data Sony tape automatically without operator intervention. Motion data analysis plots are generated for each flight line as well[5].

IV. PRECISION AUTOMATION PROCESSING

The Precision data processing generates the products according to each data processing request stored in the database via a Queue management system. The Precision data processing supports both polarimetric and interferometric data processing of up to 12 different radar modes.

The AIRSAR precision data processing system is a window-driven automation system. The state diagram of the Queue management for data processing is shown in Fig. 2. The state diagram is defined as six states: Inactive (a request from the web shopping cart), Active (job priority to be assigned by a coordinator), In-process, In-review (quality assurance), Archive and Delivery states. For the In-process state, there are four sub-states: waiting for geolocation and elevation tie-pointing, tie-pointing completed, waiting for problem solving, and problem solved. After job completion, the job queue is directly updated and emails are issued to investigators to view and download the processed imagery from an FTP site.

There are three steps for the Precision data processing: pre-processing, main-processing, and post-processing. The pre-processing is also defined as a job setup module mainly to verify the raw echo auxiliary data and motion data (making error recovering as necessary) for each data type. In the job setup module, the raw echo data are scanned and fixed line-by-line such as the anomalous range samples extraction and range samples shifting, and Radio Frequency Interference (RFI) filtering. In general, the rate of contaminated pulses is less than 0.1%; however, most 80 MHz L-band data has a digital subsystem timing glitch, which must be fixed during data processing. Most P-band data and some L-band data were affected by RFI. About 90 % of the RFI can be removed by the current RFI filtering module. An Ashtek Differential GPS and a H764G EGI were incorporated into the system

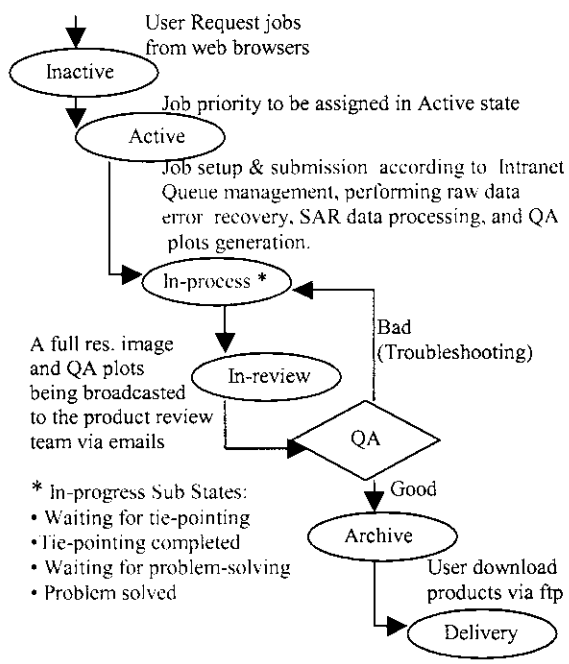

Figure 2. The State diagram of processing job

since 2000. The stability of motion data has increased from previous years. The main-processing module produces polarimetric and interferometric SAR images. The post-processing module performs data quality assurance and image mosaic processing.

V. DATA ARTIFACTS TRACKING

During data processing, data artifacts are logged into the database as well. The efficiency of error recovery is greatly improved by utilizing the artifacts log and corresponding correction steps.

The data artifacts can be classified as instrument artifacts, processing artifacts, and intrinsic data artifacts. Instrument artifacts include ADC timing delay error, ADC sample losses, receiver phase stability, radiometric compensation error, geo-location error, and digital noise filtering. Processing artifacts consist of phase discontinuity, mis-registration, patch discontinuity, motion-compensation error, and annotation error. Intrinsic data artifacts include radio frequency interference, echo multi-path, phase-unwrapping problem, azimuth ambiguities, cross-talk removal failure, and uncompensated topography.

One crucial step in a daily data processing system is the error recovery to ensure that each data request can be delivered correctly. A data artifact meeting was formed to evaluate and confirm new correction techniques. The correction steps are logged into the database to benefit future artifact resolution.

IV. DATA QUALITY ASSURANCE

All AIRSAR data acquired since 1993 are fully calibrated[6][7][8]. We developed a series of QA procedures to insure the data quality.

For each polarimetric processing job, plots were generated automatically to evaluate the POLSAR data quality including co-pol phase histogram plot, backscatter gain profile, cross-talk analysis plot, and the injected caltone phase and gain plots, etc. These analysis plots are emailed to the processing team along with the processing job status for review.

For each interferometric processing scene, a number of plots are issued via the email system, such as co-registration plot between two interferometric channel data, phase unwrapping error statistics, geo-location error statistics, mis-registration across the band (C-,L-and P-band), and V-polarization backscatter gain evaluation.

The data quality assurance procedure ensures that all delivered POLSAR images meet the absolute gain calibration accuracy of 3 dB and relatively gain calibration accuracy between frequencies of 1.5 dB . The procedure also ensures that the relative height accuracy of the TOPSAR data is within 2 to 5 m for C-band and 5 to 10 m for L-band. The procedure ensures the mean of the location error of the TOPSAR data to within 3 meters as well.

VI. CONCLUSION

AIRSAR has a fully integrated data acquisition, user request, data processing, quality assurance, archiving, and delivery system through which most components of the data fulfillment process communicate via shared information within a database. The integration of these functions has reduced operator errors and increased throughput of processed data to customers dramatically.

This integration system made a new record to deliver 35 processing requests per week with both POLSAR (polarimetric SAR) and TOPSAR (topographic SAR) data. This integrated data processing system is capable of handling all AIRSAR data modes acquired since 1993. It is also a cost-effective way to manage a robust SAR processing and archival system.

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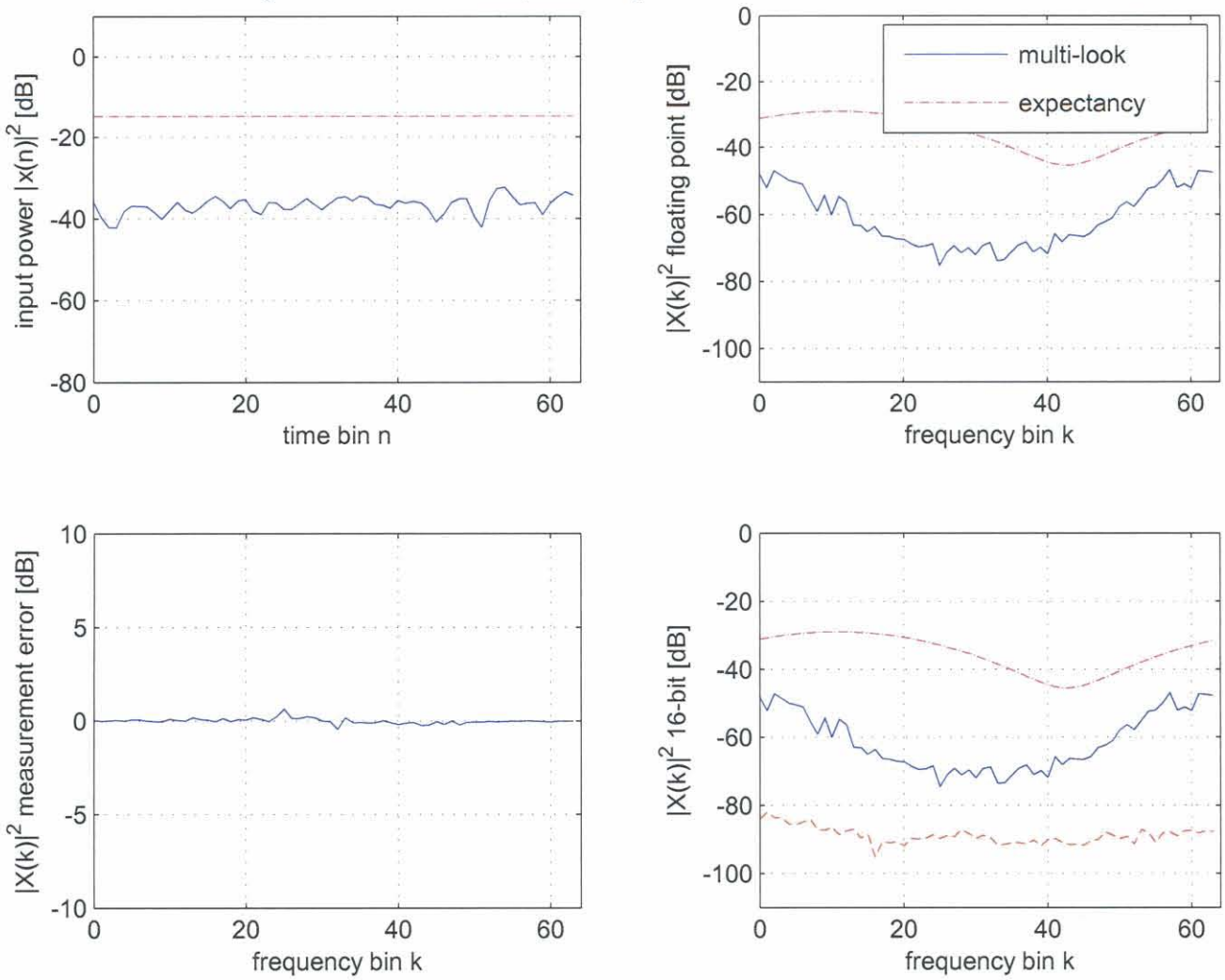
nt Doppler rain spectrum sim. (f_0=1 kHz, S=FS-10dB, σ_f=1 kHz, f_s=6 kHz, N = 8 looks)