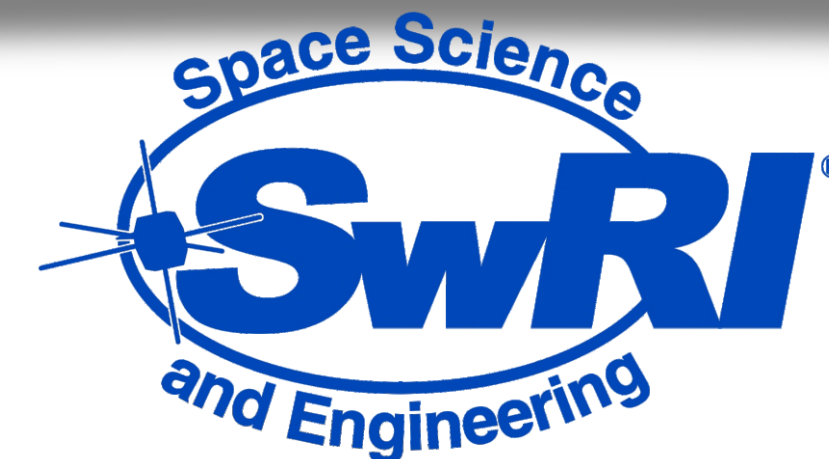


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We support the entire mission lifecycle and have developed many successful systems, including currently operating experiments on the Juno, New Horizons, Cassini, Rosetta, Mars Express, Lunar Reconnaissance Orbiter (LRO), and Magnetospheric Multi-Scale (MMS) missions. We have built systems for mission planning, instrument development, calibration, science planning, uplink sequencing, downlink management and state-of-health analysis. Additionally, these systems provide data processing pipelines and interfaces necessary for end-to-end data management from science planning to data distribution, visualization, analysis, archiving and storage.

Science Operations Centers

SwRI has developed and operated several Science Operations Centers (SOCs) with many staff members dedicated to science operations. Our responsibilities include coordinating science campaign observations and spacecraft data volume and power management, monitoring of sensor housekeeping, developing autonomous and commanded mode switching protocols, managing instrument throughput, lifetime considerations, fault protection, instrument software simulation, etc. Commanding products for use in-flight are tested on a software simulator and/or the engineering qualification model (EQM). The policy is to *"test what you fly"* and *"fly what you test"*. Tools and processes developed to perform operational planning and data processing tasks are used and adapted to support the operational requirements of any investigation.

The basic SOC infrastructure (e.g., user authentication framework, application and web interface framework, data system management) is the foundation for many science data systems produced at SwRI, with the software developed using reusable modules that are easily modified to meet the specific needs of any mission. In addition, the science operations and the data management functions are easily customized to meet the unique requirements of each science investigation.

Science Data Systems

SwRI has a long history of data processing and visualization for science analyses and data archiving, using secure, web-based ground systems. Data processing captures the raw data and converts them to engineering units and physical parameters. SwRI has a strong reputation when it comes to analyzing, verifying, and validating data sets for delivery to the public archive, such as the Planetary Data System (PDS), and for publishing science results.

The data management infrastructure is proven and the majority of the software is reusable, thus reducing time and cost in developing applications for new missions. In many cases, architects of these systems are available to tailor systems for any science investigation.

Data Management and Analysis

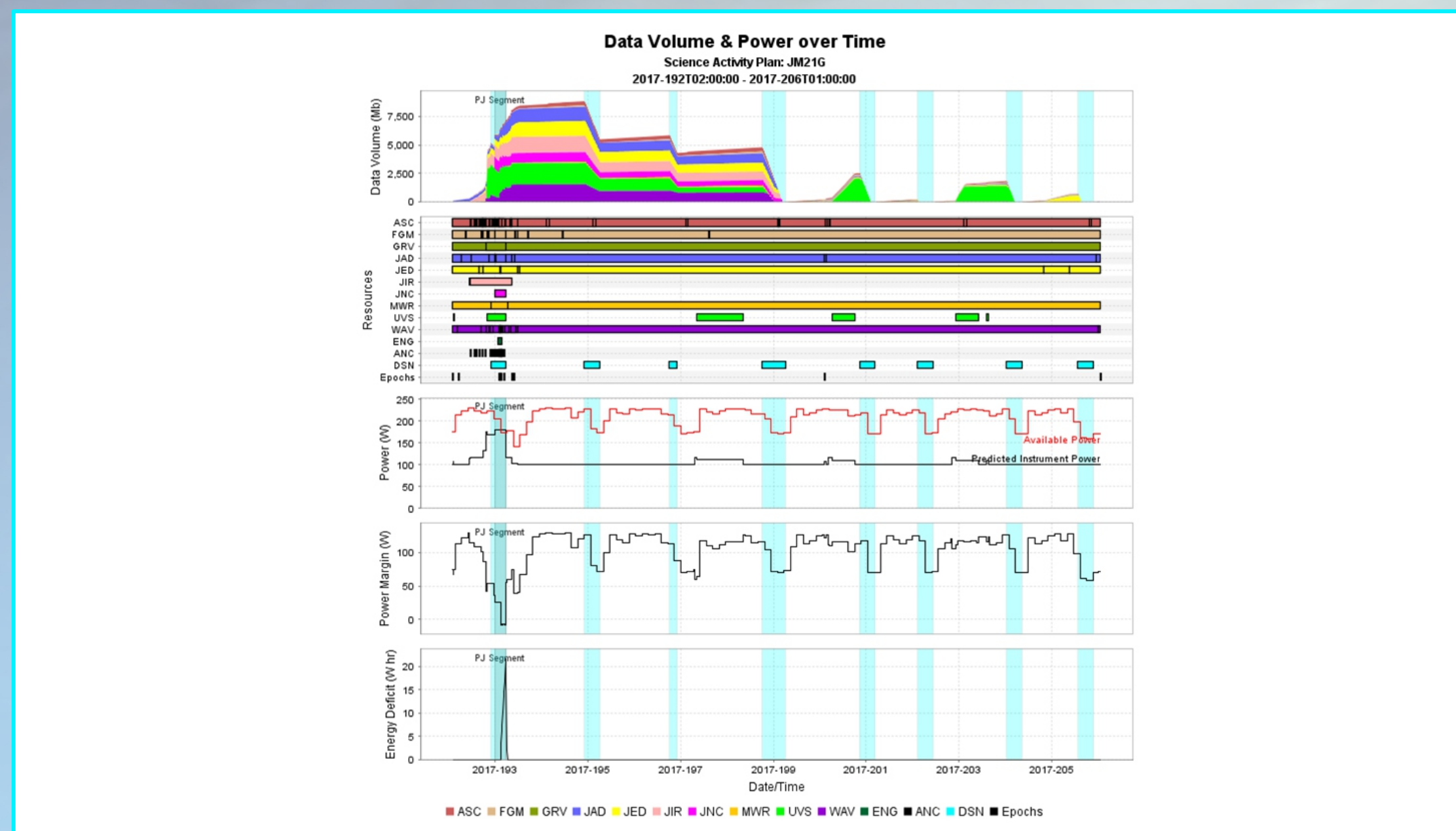
Data management includes all stages of ingesting, processing, formatting, distributing, archiving, retrieving, and mining data in automated and interactive fashions. Data analysis includes numerical computation, data fusion techniques, and visualization in a variety of 2D and 3D views.

The staff relies on more than 25 years of systems design and development experience to produce quality solutions using applicable software technologies across the span of computer science and engineering. Applications for clients are developed by applying design methodologies, rapid prototyping, and knowledge of a broad spectrum of standards.

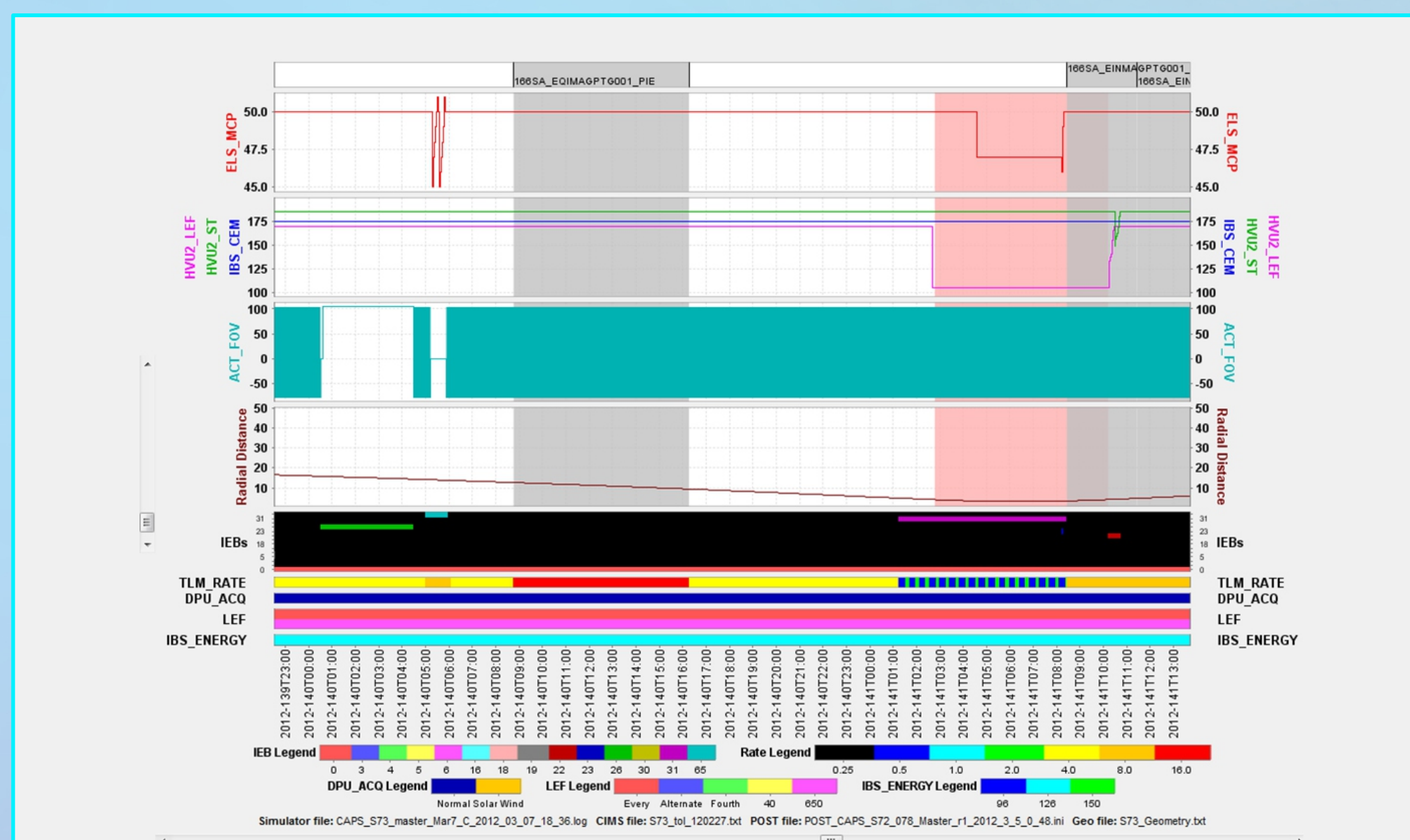
We have extensive experience with many data formats, such as CDF, FITS, ASCII, IDL Save Sets, and with various archival standards, such as the Planetary Data System (PDS) and the Space Physics Archive Search and Extract (SPASE) standards. A computer laboratory provides an adaptable development and testing environment for almost any software need. The developers use cross-platform (UNIX, Linux, Windows, Macintosh) development techniques, multiple programming and scripting languages (C/C++, FORTRAN, Tcl/Tk, Perl, PHP, Java, Lua, Python), open source tools (VTK-Visualization ToolKit, Qt/Qtw, MySQL, SQLite, PostGRES, SPICE), and proprietary tools (IDL, MATLAB, Mathematica®, SIMION®) to develop analysis, visualization (2D/3D), data fusion and mining applications both on and off the web.

Conclusion

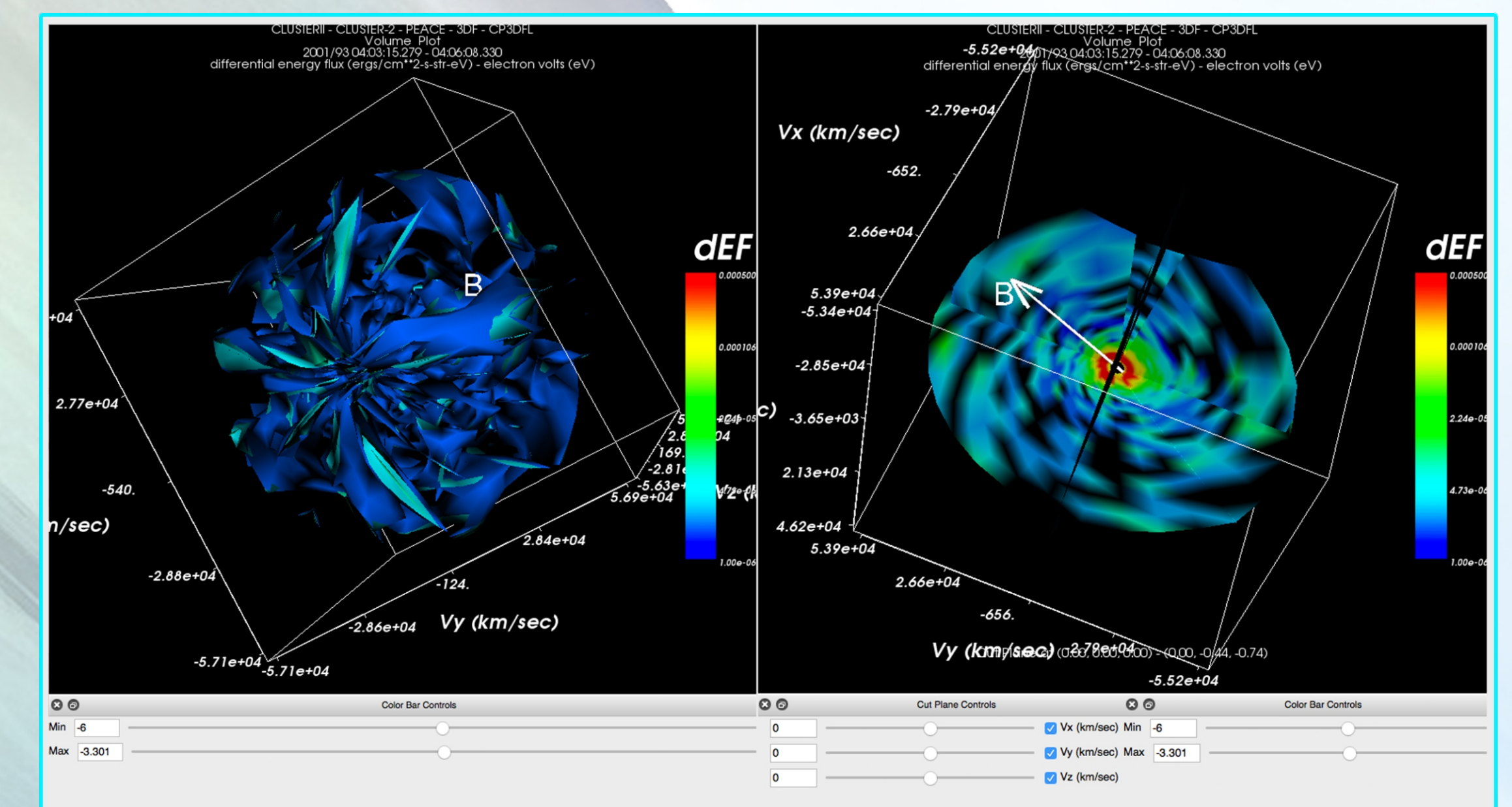
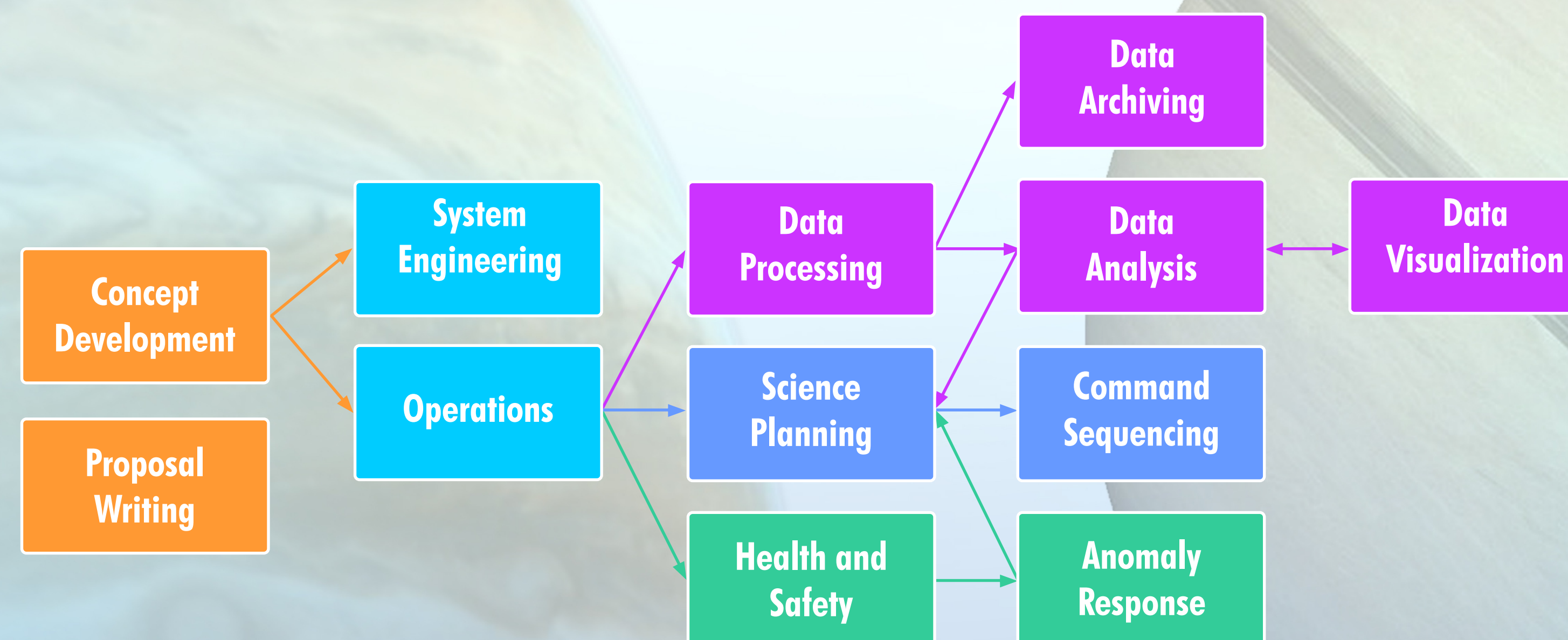
The SODAS section at SwRI has the experience, processes, and the infrastructure to design and develop cost-efficient science operations and data management systems for new missions and science investigations using appropriate technologies.



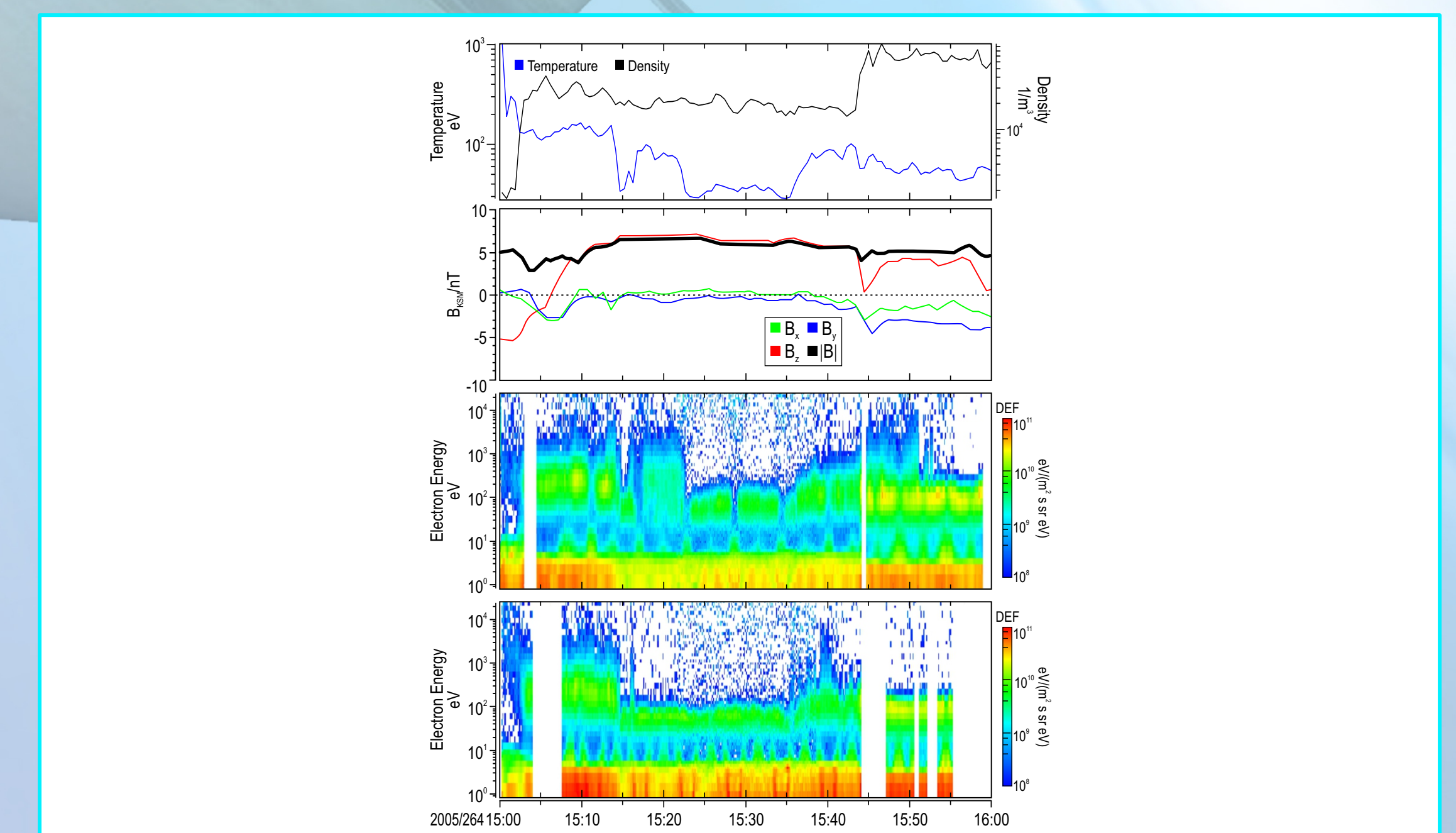
Juno Data Volume and Power Profile: Results of payload data volume and power modeling performed by the Juno Science Operations Center (JSOC) data system. The data volume model uses data rates from instrument activities, mass memory partition sizes and DSN passes to generate downlink priorities, data storage and return profiles to avoid data loss. The integrated power from instrument activities is compared against the predicted available power to determine power margins, battery usage and avoid power systems safety risks.



Visual Command Sequencing Validation Tool: Example of the output from a sequence validation tool developed for the Cassini Plasma Spectrometer (CAPS) instrument. It integrates multiple commanding products to generate timelines of instrument subsystem states, telemetry profile, pointing profile as well as execution timeline of internal macros and background sequence requests. This serves as a final visual validation of products prior to delivery for uplink.



Three Dimensional Data Visualization: Electron data from the PEACE instrument on the second Cluster satellite. The first image is the full 3D distribution function. Isosurfaces are drawn throughout the distribution similar to isolines on a contour function. One can see some structure, but when one cuts into the distribution, more details are visible. The magnetic field vector is overlaid onto the plot in the PEACE frame. Each visualization is fully interactive in terms of view, colors, or cut planes.



Scientific Data Analysis: (first to fourth panels) The electron density and temperature, magnetic field, and electron energy-time spectrograms at 0° – 45° and 135° – 180° pitch angles. The spacecraft transitions from the magnetosphere on the left-hand side to the magnetosheath on the right-hand side. It makes a single, slow crossing of the magnetopause current layer during the 1 h interval. The spectral data was derived from the publicly available CAPS data combined with the publicly available FGM data from the PDS archive.