International Space Station Power Planning and Analysis Tool

Molly Meyer-Allyn, *Johnson Space Center*
Dan Jackson, *Barrios Technology, Inc.*
Michael Genest, *United Space Alliance*
Thomas Miller, *Barrios Technology, Inc.*
Benjamin Chisholm, *United Space Alliance*
Aaron Allcorn, *Johnson Space Center*

The individuals supporting the International Space Station (ISS) from the Mission Control Center are known for their ability to manage complex systems, minimize error, and maximize success. Another innate ability that exists is to look for better, more innovative ways to accomplish day-to-day mission goals.

The Power Planning and Analysis Tool (PLATO) is one such innovation. PLATO is a single, integrated tool with a simple and intuitive user interface that will be used to perform analysis and planning of the generation, storage, and use of electrical power/energy onboard the ISS (figure 1). It will provide users with the ability to complete an end-to-end, 7-day International Space Station power analysis in 2 hours or less—a roughly five-fold decrease in the current time required. Its goals are to consolidate all current power planning tools under the PLATO umbrella; highly automate application setup, execution, and output display; simplify user interfaces; and simplify interfaces with providers of external inputs—the U.S. Operating Segment Systems, operations planners, payload planners, and international partners. Even as it makes ISS power planning much more expeditious, PLATO will maintain the same robust level of computational fidelity/accuracy as the current power analysis toolset.

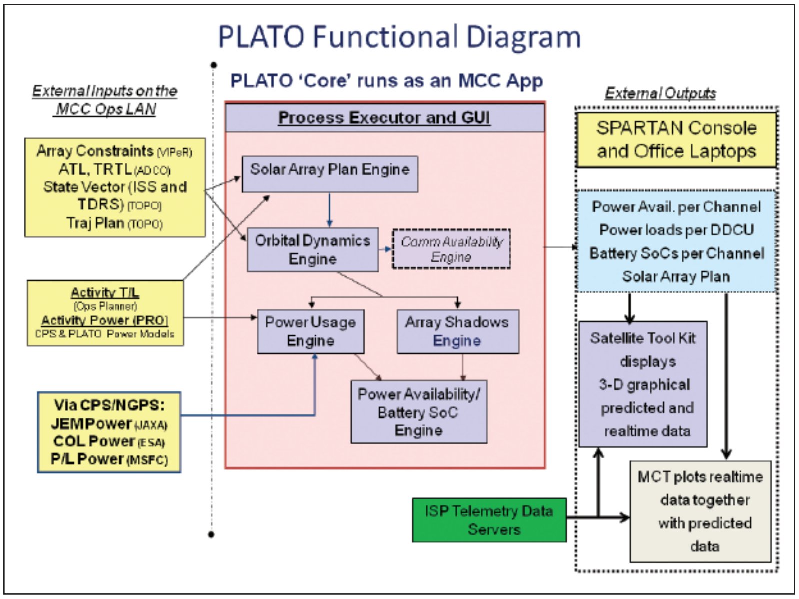

Fig. 1. The Power Planning and Analysis Tool (PLATO) functional diagram.

The power planning process that exists today uses nine separate applications involving an average of 20 hours of human interaction to complete a weekly plan. As a result of the efficiency to be provided by this tool, the ISS Power and External Thermal Systems Branch will be able to reduce its sustaining workforce by three people. This simplified and more automated process also mitigates the risk of human error that is present with the current, more manpower-intensive process.

The main internal components of PLATO consist of the following:

- ***Integrator/Graphic User Interface*** seamlessly integrates all the other components within the tool and eliminates or minimizes user involvement needed to complete end-to-end analysis after initial inputs have been made. It provides the user with an easy way to model complex operations and contingency scenarios and perform iterative "what-if" assessments for both. It also provides the user with a simple and fast way to define power downs and to determine the effects of power downs on channel/direct current to direct current converter unit power levels and battery states of charge (SoC).
- ***Solar Array Constraint Engine*** uses the attitude timeline, thruster configuration files, and ISS state vector to correlate mission timeline events with calculated array constraint matrices and constructs an optimized solar array plan that satisfies all solar array constraints while providing the optimal amount of power generation capability.

International Space Station Power Planning and Analysis Tool

continued

- ***Orbital Dynamics Engine*** propagates trajectory ephemeris from a state vector and trajectory plan, determines orbital sunrise/sunset times, calculates array pointing angles from the attitude timeline and solar array plan, and generates the integrated joint state file, which includes all the ISS solar array/sun angles as a function of time as well as other pertinent data files.
- ***Array Shadowing Engine*** uses satellite tool kit to process a three-dimensional graphical model of the ISS, orbital day/night data, and the integrated joint state file to determine shadow patterns on each solar array as a function of time. It then passes specific shadow pattern data for each solar array to the power availability engine.
- ***Power Usage Engine*** reads the appropriate ISS activity timeline from the ISS ops planner tools (Consolidated Planning System/ Next Generation Planning System), associated attitude, orbital beta angle, and sunrise/sunset data, Electrical Power System architecture configuration data, activity-specific power usage data, and inputs on power usage of the international partner modules and payloads, and then calculates total electrical loads as a function of time at various levels within the power distribution architecture.
- ***Power Availability/Battery SoC Engine*** calculates power availability and/or battery SoC as a function of time based on a defined power loads profile. In power availability mode, it calculates the total electrical load each channel can support given the amount of solar flux illuminating the solar arrays during insolation and the rate of discharge of the batteries during eclipse over each orbit in the analysis timeline without violating minimum operational SoC limit. In battery SoC mode, it determines the resultant battery SoC given the electrical loads per power channel, the amount of solar flux illuminating the arrays during insolation, and the rate of discharge of the batteries during eclipse for each orbit in the timeline.

Once operational, PLATO is expected to be equally accessible to users from multiple locations including the office environment, Mission Control Center/Mission Control-Houston, and all relevant training environments. Input and output data will flow freely between environments and platforms, including those associated with external sources of input data such as international partners and Marshall Space Flight Center/payloads.

In addition to its primary function as a power planning tool, PLATO will also have some capability to support real-time operations. It will be able to compare selected telemetry values pertinent to power resource management and to compare those values to the PLATO predictions. It will then notify the user—the SPARTAN flight controller—if there are significant deviations between actual and predicted values or developing trends that could lead to such a deviation.