plex flight profile to be simulated, as well as ambient conditions and deterioration level of the engine. C-MAPSS40k has three actuators: fuel flow, variable stator vanes, and variable bleed valve. The three actuators enable off-nominal operation, which is not possible with simulations that have fuel flow as the sole actuator, since in those simulations the other actuators are implicit and assumed to operate nominally. The simulation is modular to allow users to redesign or replace components such as the engine controller or turbomachinery components without having to modify the rest of the simulation. It also enables the user to view and save any signal in the engine or controller. The package has the capability to create and validate a linear model of the engine at any operating point. Linear models can be used for control design, and C-MAPSS40k lends itself well to implementation and evaluation of advanced control designs as well as to diagnostic and prognostic system development. The simulation can be run in real time and can therefore be integrated into a flight simulator with a pilot in the loop for testing.

C-MAPSS40k fills the need for an easy-to-use, realistic, transient simulation of a medium-size commercial turbofan engine with a representative controller. It is a detailed component level model (CLM) written in the industry-standard graphical MATLAB/Simulink environment to allow for easy modification and portability. At the time of this reporting, no other such model exists in the public domain.

This work was done by Ten-Huei Guo, Thomas Lavelle, and Jonathan Litt of Glenn Research Center and Jeffrey Csank of N&R Engineering and Ryan May of ASRC. Further information is contained in a TSP (see page 1).

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steven Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18624-1.

The Planning Execution Monitoring Architecture

Lyndon B. Johnson Space Center, Houston, Texas

The Planning Execution Monitoring (PEM) architecture is a design concept for developing autonomous cockpit command and control software. The PEM architecture is designed to reduce the operations costs in the space transportation system through the use of automation while improving safety and operability of the system. Specifically, the PEM autonomous framework enables automatic performance of many vehicle operations that would typically be performed by a human. Also, this framework supports varying levels of autonomous control, ranging from fully automatic to fully manual control.

The PEM autonomous framework interfaces with the "core" flight software to perform flight procedures. It can either assist human operators in performing procedures or autonomously execute routine cockpit procedures based on the operational context. Most importantly, the PEM autonomous framework promotes and simplifies the capture, verification, and validation of the flight operations knowledge. Through a hierarchical decomposition of the domain knowledge, the vehicle command and control capabilities are divided into manageable functional "chunks" that can be captured and verified separately. These functional units, each of which has the responsibility to manage part of the vehicle command and control, are modular, re-usable, and extensible. Also, the functional units are self-contained and have the ability to plan and execute the necessary steps for accomplishing a task based upon the current mission state and available resources.

The PEM architecture has potential for application outside the realm of spaceflight, including management of complex industrial processes, nuclear control, and control of complex vehicles such as submarines or unmanned air vehicles.

This work was done by Lui Wang, Bebe Ly, and Alan Crocker of Johnson Space Center; Debra Schreckenghost of Metrica Inc; Stephen Mueller and Bob Phillips of Titan-LinCom Corp.; and David Wadsworth and Charles Sorensen of Lockeed Martin Corp. For further information, contact the Johnson Commercial Technology Office at (281) 483-3809. MSC-23628-1

Jitter Controller Software

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Sinusoidal jitter is produced by simply modulating a clock frequency sinusoidally with a given frequency and amplitude. But this can be expressed as phase jitter, frequency jitter, or cycle-to-cycle jitter, rms or peak, absolute units, or normalized to the base clock frequency. Jitter using other waveforms requires calculating and downloading these waveforms to an arbitrary waveform generator, and helping the user manage relationships among phase jitter crest factor, frequency jitter crest factor, and cycle-to-cycle jitter (CCJ) crest factor.

Software was developed for managing these relationships, automatically configuring the generator, and saving test results documentation. Tighter management of clock jitter and jitter sensitivity is required by new codes that further extend the already high performance of space communication links, completely correcting symbol error rates higher than 10 percent, and therefore typically requiring demodulation and symbol synchronization hardware to operating at signal-to-noise ratios of less than one. To accomplish this, greater demands are also made on transmitter performance, and measurement techniques are needed to confirm performance. It was discovered early that sinusoidal jitter can be stepped on a grid such that one can connect points by constant phase jitter, constant frequency jitter, or constant cycle-cycle jitter. The tool automates adherence to a grid while also allowing adjustments off-grid. Also, the jitter can be set by the user on any dimension and the others are calculated. The calculations are all recorded, allowing the data to be rap-