INTRODUCTION
Cognitive performance and alertness of astronauts are affected during a long duration space flight due to the unusual light/dark and sleep/wake schedules to which they are exposed, often resulting in a circadian misalignment with respect to their work schedules. To improve astronauts’ performance and sleep quality, light exposure can be carefully scheduled as a safe countermeasure to realign their circadian rhythms to match their sleep/wake schedules. To design and modify lighting schedules for circadian alignment and performance improvement we have developed a mathematical model of the effects of light on the human circadian pacemaker [1,2] and incorporated this model into our mathematical Neurobehavioral Performance Model [3]. To further refine and validate these models we have proposed the following Specific Aims: Aim 1: To further develop and refine our Light Model using data from four studies of the effects on the human circadian system of different stimulus cycles of brief or extended and bright- or moderate-intensity light pulses. Aim 2: To validate the Light Model refined above in Aim 1 using data from four different studies of the effects on the human circadian system of single-cycle patterns of brief or extended bright light pulses and of sleep-wake/light-dark schedules with a wide range of periods. Aim 3: To incorporate the Light Model into our Neurobehavioral Performance Model and validate this model using data from the above 8 studies. Aim 4: To develop a user-friendly Circadian Performance Simulation Software (CPSS) for field applications.

METHODS
At present we are focusing on the refinement and validation of our Light Model using two approaches: 1) Using statistical time series analysis, we have expressed one marker of circadian clock, Core Body Temperature (CBT) collected under Constant Routine conditions, as mathematical model consisting of a circadian signal plus thermoregulatory noise [4]. Signal in the model is obtained by the numerical solution of the Light Model, and noise is represented as an autoregressive process (AR). The parameters of the model are obtained by optimizing a likelihood function of the model using Newton’s procedure along with a Kalman Filter. Statistical tests are used to assess the goodness-of-fit of the model with the experimental data. We are using this signal-plus-noise model (STAT) to study the amplitude recovery dynamics seen in CBT following amplitude suppression from a critical light stimulus. 2) In our second approach we fit six different “Two Harmonic” models (TH) directly to CBT data with and without AR processes with dependent and independent growth factors for each harmonic. STAT model’s ability to detect the amplitude recovery in experimental data is limited by the parameters of Light model, whereas in TH models it depends on the form of growth factors. Therefore, comparing the results obtained by both methods will allow us to more thoroughly understand the amplitude recovery dynamics of the human circadian oscillator.

RESULTS and FUTURE PLANS
1) The STAT model successfully extracts the low amplitude circadian signal from the noisy CBT data and allows us to compare two published differential equation Light Models, (Simpler [4] and Higher-Order [1]) on a common statistical modeling framework. Our preliminary analysis indicates that the Higher-Order model gives a better fit to low temperature data. However, we also found that in some cases the dynamics of the Light Model are dependent upon AR process used. This indicates that there is an interaction between the thermoregulatory system and the circadian system. 2) When we fit the TH models without AR processes we found the best fit to the data when the two harmonics had independent exponential factors, suggesting that that there is a dominant second harmonic component in the CBT data that must be taken into account in these models. We now plan to develop and test a nonlinear dynamical model of CBT data that includes the interaction between the circadian and thermoregulatory systems, and contains a second harmonic CBT component.