

# INTEGRATED CREW PERFORMANCE ASSESSMENT AND TRAINING

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## INTRODUCTION

As future space missions become longer and more complex, the human performance requirements associated with those missions will change. Detailed training for all mission tasks will not be completed pre-flight, but in many cases will be delivered "just-in-time" (JIT). The anticipated changes in mission requirements, when coupled with the anticipated changes in operator state associated with the longer mission, will accentuate the importance of an advanced accurate performance assessment system. An integrated system that would also present recommendations for new or refresher training for upcoming activities would provide even greater utility.

Full implementation of the integrated system would be based on knowledge of all planned mission activity, the relevant timeline, and identification of all critical tasks. Task analysis (including cognitive task analysis) applied to each critical task would be used to determine the component capabilities and skills essential for successful completion of the task. A project management critical path approach would be applied to determine critical lead times for new or refresher training in the requisite skills (perhaps involving on-board simulator training). Based on a model of skill acquisition and decay/retention for the critical skills, the level and timing of refresher training would be prescribed to guarantee that the minimum level of proficiency is achieved prior to the scheduled time for the operational task. A similar framework exists with respect to the diagnosis of risk factor effects and the prescription of countermeasure interventions. Critical to the success of the overall system is the development of the assessment instrument. The development of this instrument forms the starting point for our research.

## RESEARCH PROGRAM

### Research Objectives

The overall objective of the research is to further the self-assessment of astronaut cognitive and sensorimotor state as it relates to crew performance, and to prescribe training and countermeasure interventions based on the assessments. In the arena of self-assessment, it is important for each astronaut to determine his or her current state in relation to individual capacity. This necessitates an assessment of reserve capacity in a relevant mission setting. Traditionally, reserve capacity has often been assessed using a secondary task method. In contrast, the proposed solution in this research is the development of "dynamic load" tasks, whose level of difficulty changes as the task progresses. The research approach involves innovative transformation of traditional cognitive assessment tasks to measure critical limits at the time of testing in relation to an unstressed baseline obtained at the maximum trained proficiency.

The focus of the research is the development of an integrated system for self-assessment of cognitive state followed by intervention prescription. The research hypothesis is that appropriately constructed dynamic load tasks and highly-integrated complex tasks will reveal cognitive decrements sooner than simple tasks (i.e., at an earlier point of training

proficiency loss or at a lower exposure to the risk factor). This hypothesis will be tested by comparing the sensitivity of dynamic load (i.e., critical-type) tasks with the sensitivity of simple static load tasks comprising similar task elements to time-induced skill decay and fatigue-induced changes in cognitive and visuomotor state.

#### Previous Research

One of the most comprehensive studies of on-orbit cognitive and psychomotor performance changes was conducted by Schiflett, Eddy, Schlegel, and Shehab using the NASA Performance Assessment Workstation (PAWS), a computerized battery of performance assessment tasks. The research focused on the assessment of the effects of microgravity and other space flight risk factors on cognitive and visuomotor performance during short-duration space shuttle missions (IML-2 and LMS). Reductions in visuomotor and cognitive performance as a function of gravity changes and fatigue were most noticeable when assessed using complex tasks involving directed attention and time-sharing resources. In this and other space flight research, simple cognitive tasks have demonstrated minimal sensitivity to space flight risk factors.

#### YEAR 1 COMPLETED ACTIVITIES

The following activities were completed during the first year of this three-year research program.

##### Review of Cognitive Performance Assessment State-of-the-Art

A review of the current state of cognitive performance assessment tools was conducted through a review of the published literature, internet searches, and attendance at relevant meetings sponsored by NATO, the US Army, and small businesses. Schlegel and Gilliland serve as U.S. representatives to a NATO RTO Task Group on Operator Functional State Assessment and also provide support for the development of the Automated Neuropsychological Assessment Metrics battery of cognitive performance assessment tests. Although the approach of dynamic parameter testing has been discussed, it has not been previously implemented to the best of our knowledge.

##### Remote Manipulator System Dynamic Skills Trainer

An essential precursor of validating the assessment system is the identification of a relevant complex NASA operational task with an available high-fidelity simulator. The Remote Manipulator System (RMS robot arm) was the system of choice due to the complexity of the task requirements and the anticipated availability of BORIS (Basic Operational Robotics Instructional System) in January 2001 (actually released in November 2001). Following selection of the RMS, a review of previous cognitive task analyses of the RMS confirmed that the assessment of visuomotor performance was a top priority in ensuring successful accomplishment of RMS tasks. This led to the selection of a dynamic load tracking task for the self-assessment of visuomotor state as the first module of the assessment system.

##### Development of Tracking Task Dynamics and Implementation of Task

The work of McRuer, Jex, and others in the late 1950's and 1960's forms the basis of modeling and evaluating the human operator in dynamic control systems. An extensive review of this seminal line of research and current day implementations of unstable and

critically unstable tracking tasks was conducted to identify inconsistencies in implementation and to ensure the use of accurate controlled element dynamics in our self-assessment tracking task. In addition, tracking task variations incorporated by Manzey et al. to evaluate cosmonaut tracking performance were incorporated. These variations involved the addition of an input forcing function to the unstable tracking system, thus allowing the computation of operator gain and phase lag, which are indicative of fatigue-induced performance changes. Several variations of the tracking task were developed using combinations of elements affecting the difficulty of the task.

#### Evaluation of Task Sensitivity Using Sleep Deprivation

Eight variations of the new tracking task were evaluated using eight participants in a 36-hour sleep deprivation study. Although data analysis of all eight task variations has not been completed at the time of this writing, preliminary results confirm differences in operator gain or phase lag accompanying reduced performance for at least some of the task variations. Final analysis will result in the selection of the task form and parameters that maximize the sensitivity of the task with respect to sleep deprivation effects.

#### YEAR 2 PLANNED RESEARCH ACTIVITY

In Year 2, participants will be tested using the self-assessment system. In addition to expanding the database for evaluating task reliability and validity, this segment of the study forms the primary test of the research hypotheses. Once trained, participants will also engage in one of two additional studies to evaluate the effects of training decay or risk factors. By the end of Year 2, a validated cognitive performance assessment and training intervention system in the area of visuomotor skill will be available for incorporation in the BIO-Plex, an excellent test-bed for isolation and confinement effects. The self-assessment system can be introduced as part of the daily routine, including extended periods with minimal training on future operational tasks, and can assess the impact of risk factors related to fatigue and sleep loss.

#### YEAR 3 PLANNED RESEARCH ACTIVITY

Year 3 will focus on a multivariate expansion of the system to develop additional dynamic load tasks in the areas of spatial processing, directed attention, time sharing and resource allocation, along with a multivariate scoring approach to assess readiness to perform.